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(54) INTERCEPTING NETWORK TRAFFIC ROUTED BY VIRTUAL SWITCHES FOR SELECTIVE SECURITY PROCESSING

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(51) **Int. Cl.**

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H04L 12/26	(2006.01)
H04L 12/931	(2013.01)
G06F 9/455	(2018.01)
H04L 12/46	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 63/0254*** (2013.01); ***H04L 43/028*** (2013.01); ***H04L 49/70*** (2013.01); ***H04L 63/0236*** (2013.01); ***H04L 63/0245*** (2013.01); ***H04L 63/0272*** (2013.01); ***H04L 63/1408*** (2013.01); ***H04L 63/304*** (2013.01); ***H04L 63/306*** (2013.01); *G06F 2009/45587* (2013.01); *G06F 2009/45595* (2013.01); *H04L 12/4641* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

Systems, methods, and apparatuses enable an interface microservice to intercept and filter network traffic generated by virtual machines (VMs) and routed by a virtual switch (vSwitch). A vSwitch receiving network packets from the VMs is configured to route network packets to the interface microservice via a generated VLAN trunk. The interface microservice can retrieve and apply stored packet filters to the network packets intercepted by the microservice. If an intercepted network packet matches any of the applied packet filters, the interface microservice can perform various security operations, send the network packets to another microservice for security processing, or perform any other operations. For network packets which do not match a packet filter, the interface microservice forwards the packets to the originally intended destination.

21 Claims, 15 Drawing Sheets

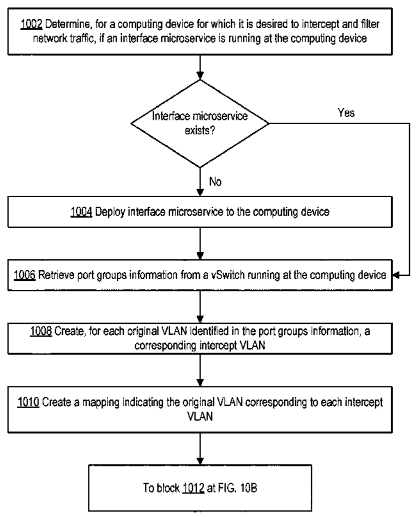

1002 Determine, for a computing device for which it is desired to intercept and filter network traffic, if an interface microservice is running at the computing device
Interface microservice exists?
Yes
No
1004 Deploy interface microservice to the computing device
1006 Retrieve port groups information from a vSwitch running at the computing device
1008 Create, for each original VLAN identified in the port groups information, a corresponding intercept VLAN
1010 Create a mapping indicating the original VLAN corresponding to each intercept VLAN
To block 1012 at FIG. 10B

FIG. 1

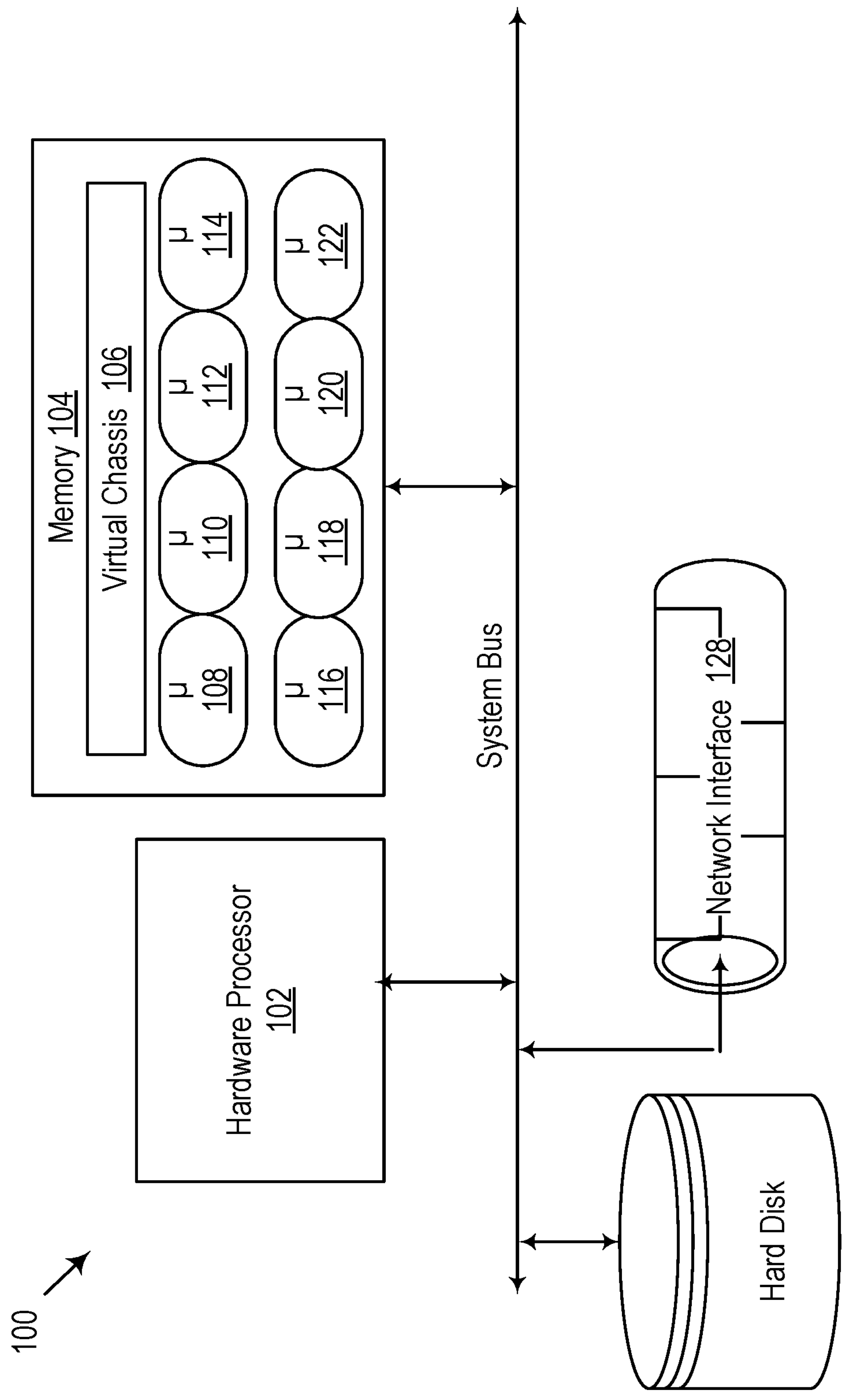

100
Hardware Processor 102
Memory 104
Virtual Chassis 106
μ 108
μ 110
μ 112
μ 114
μ 116
μ 118
μ 120
μ 122
System Bus
Network Interface 128
Hard Disk

FIG. 2

3x DPI Service Scale Out with Scalable Microservices

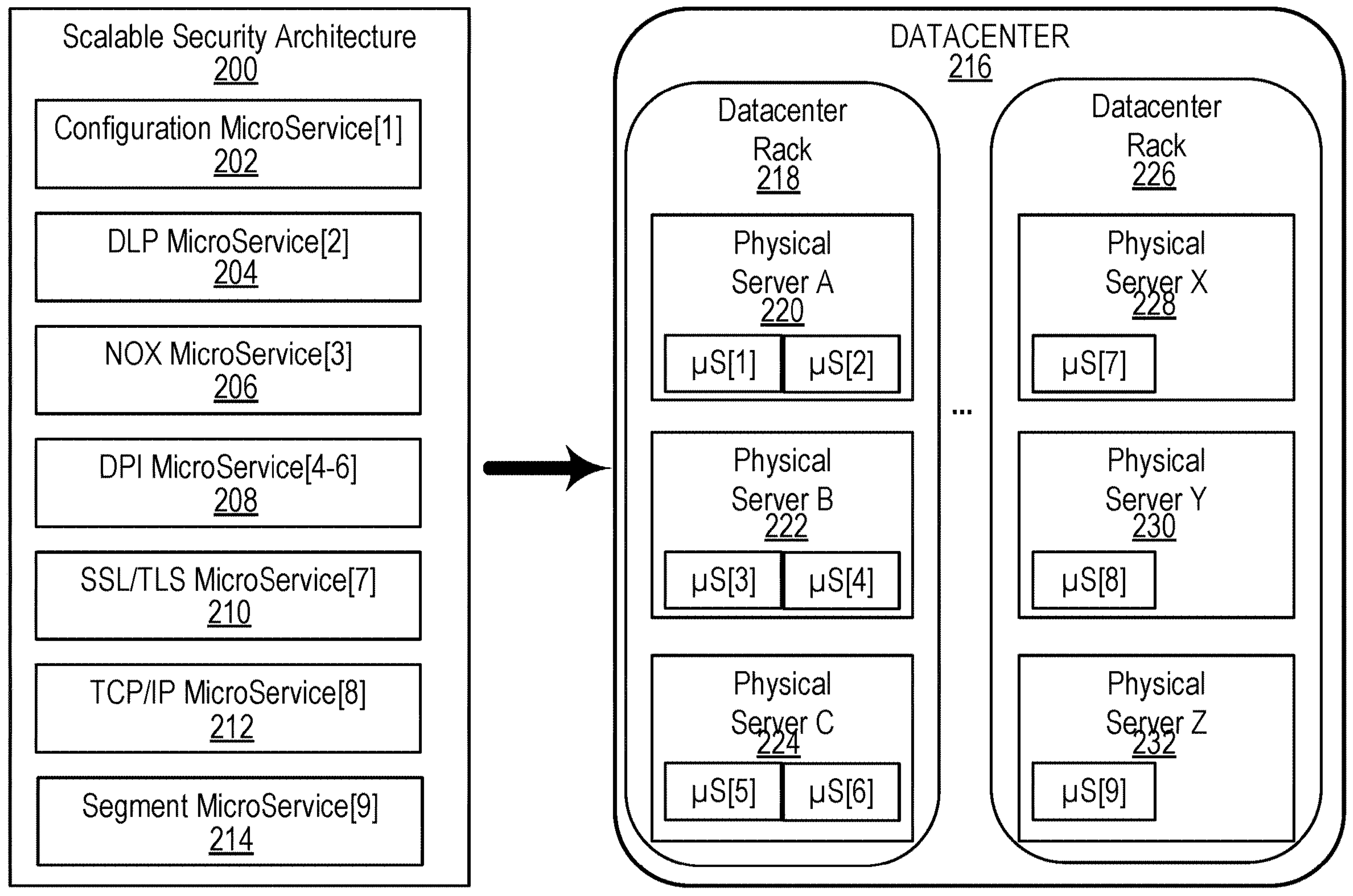
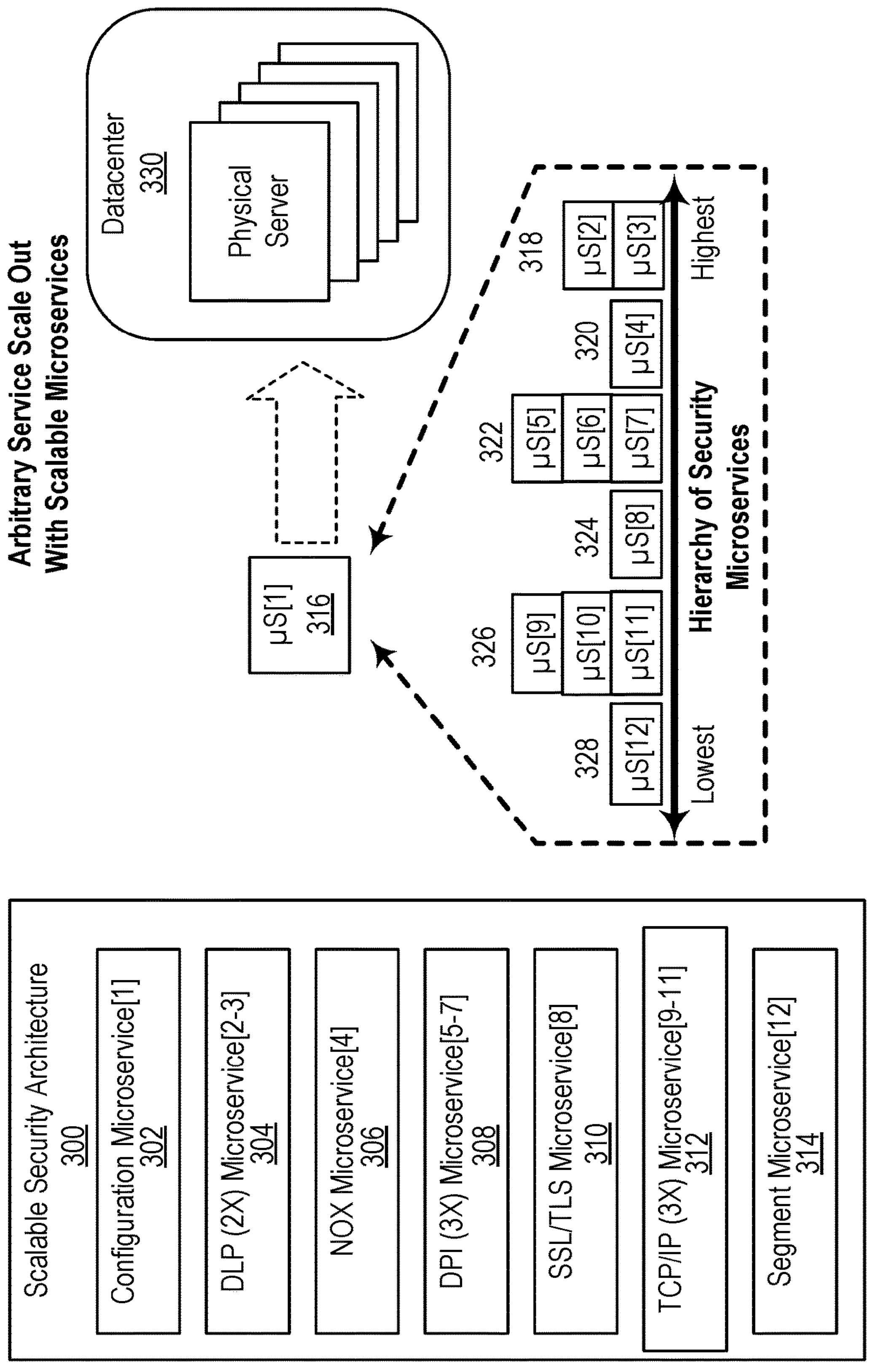


FIG. 3


Arbitrary Service Scale Out With Scalable Microservices
Datacenter 330
Physical Server
μS[1] 316
318
320
322
324
326
328
μS[2]
μS[3]
μS[4]
μS[5]
μS[6]
μS[7]
μS[8]
μS[9]
μS[10]
μS[11]
μS[12]
Highest
Lowest
Hierarchy of Security Microservices
Scalable Security Architecture 300
Configuration Microservice[1] 302
DLP (2X) Microservice[2-3] 304
NOX Microservice[4] 306
DPI (3X) Microservice[5-7] 308
SSL/TLS Microservice[8] 310
TCP/IP (3X) Microservice[9-11] 312
Segment Microservice[12] 314

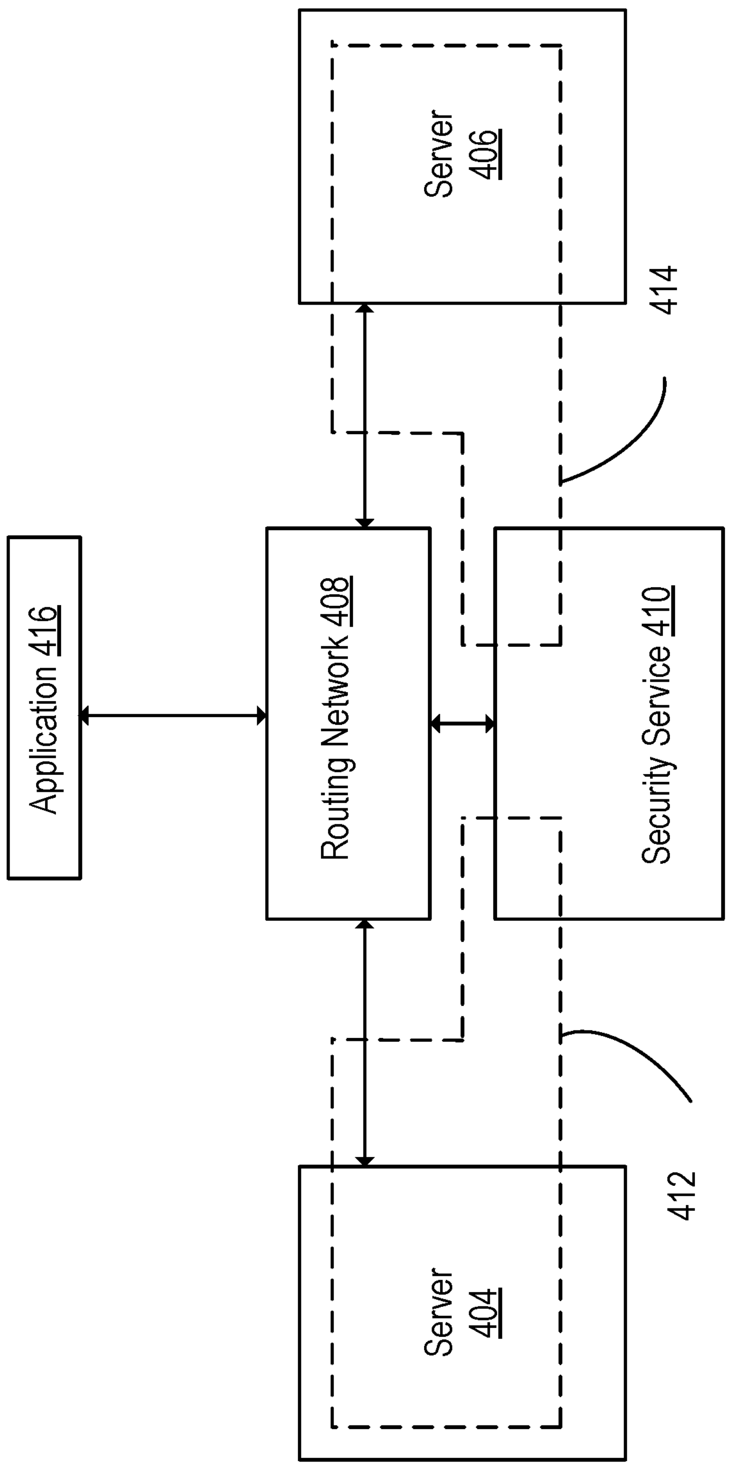

Application 416
Routing Network 408
Security Service 410
Server 406
Server 404
414
412

FIG. 4

FIG. 5

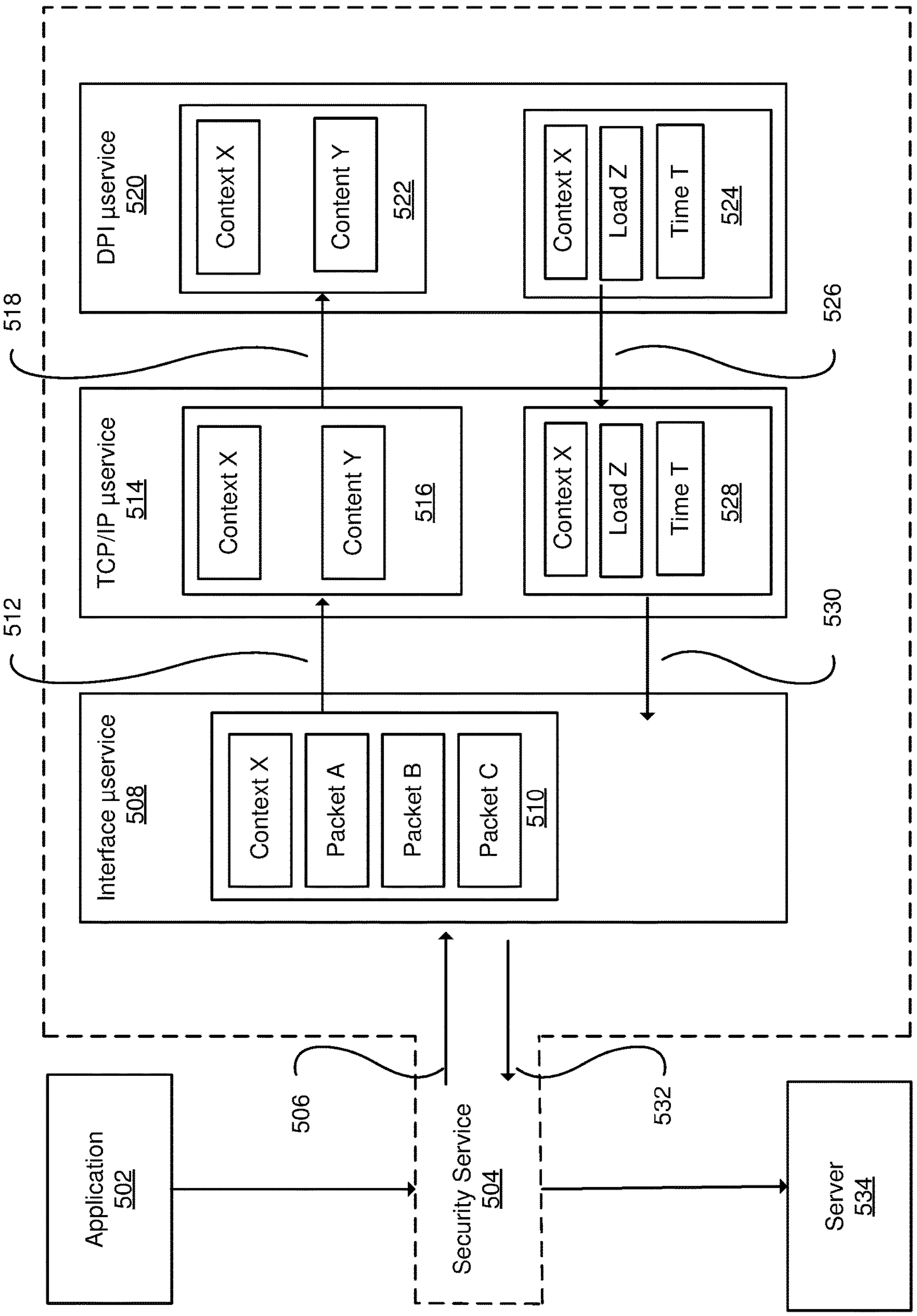

Application
502
506
Security Service
504
532
Server
534
Interface µservice
508
Context X
Packet A
Packet B
Packet C
510
512
TCP/IP µservice
514
Context X
Content Y
516
Context X
Load Z
Time T
528
530
518
DPI µservice
520
Context X
Content Y
522
Context X
Load Z
Time T
524
526

FIG. 6

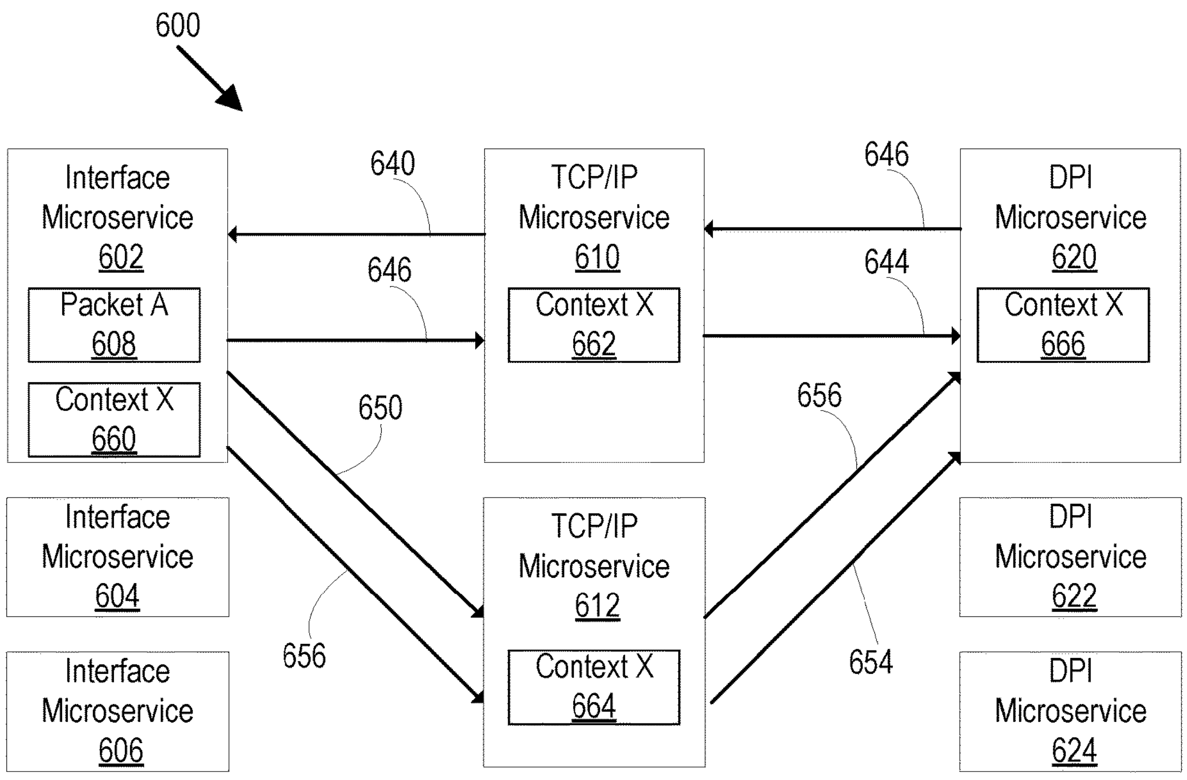

600
Interface Microservice 602
Packet A 608
Context X 660
Interface Microservice 604
Interface Microservice 606
TCP/IP Microservice 610
Context X 662
TCP/IP Microservice 612
Context X 664
DPI Microservice 620
Context X 666
DPI Microservice 622
DPI Microservice 624
640
646
650
656
646
644
656
654

FIG. 7

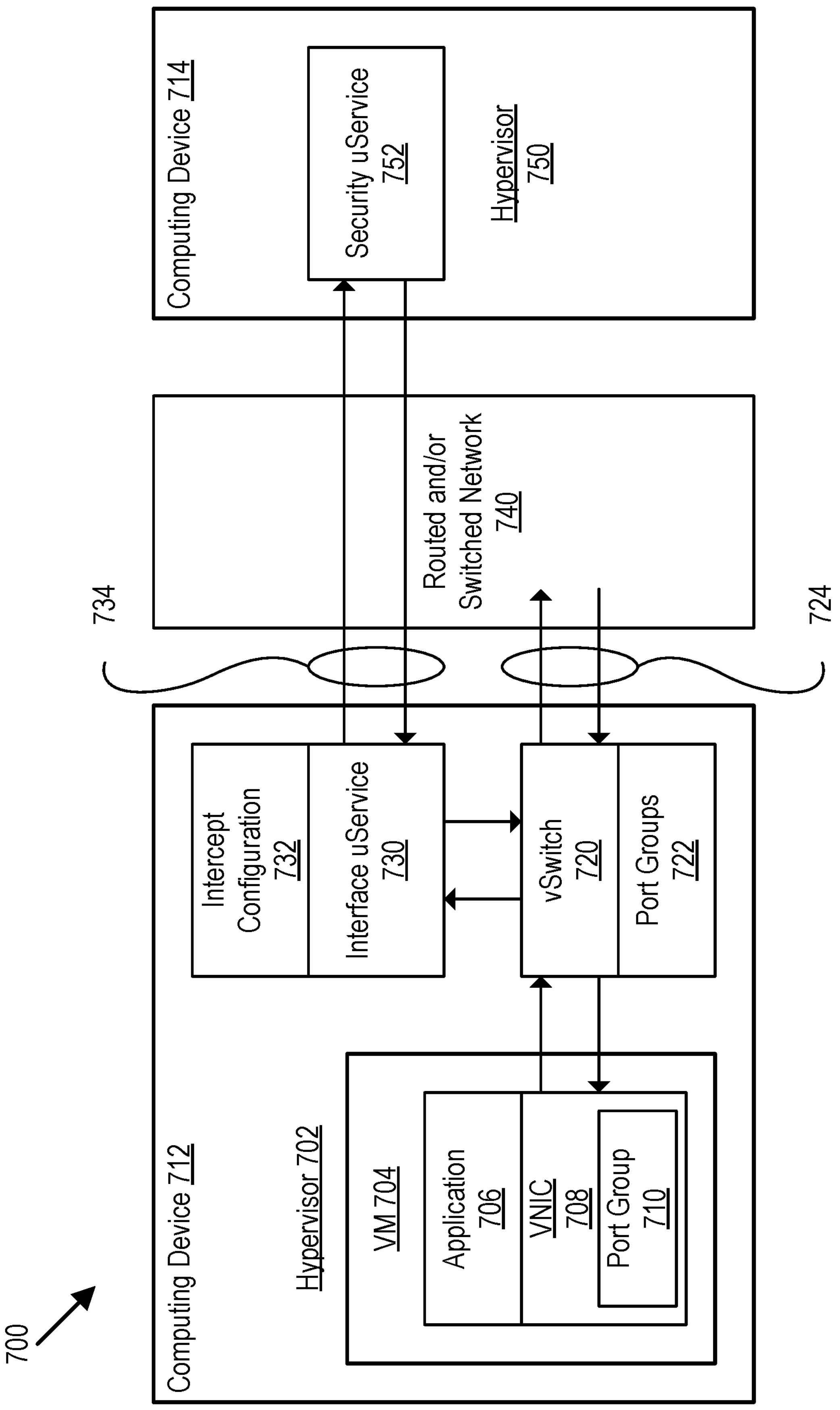

700
Computing Device 712
Hypervisor 702
VM 704
Application 706
VNIC 708
Port Group 710
Intercept Configuration 732
Interface uService 730
vSwitch 720
Port Groups 722
734
724
Routed and/or Switched Network 740
Computing Device 714
Security uService 752
Hypervisor 750

FIG. 8

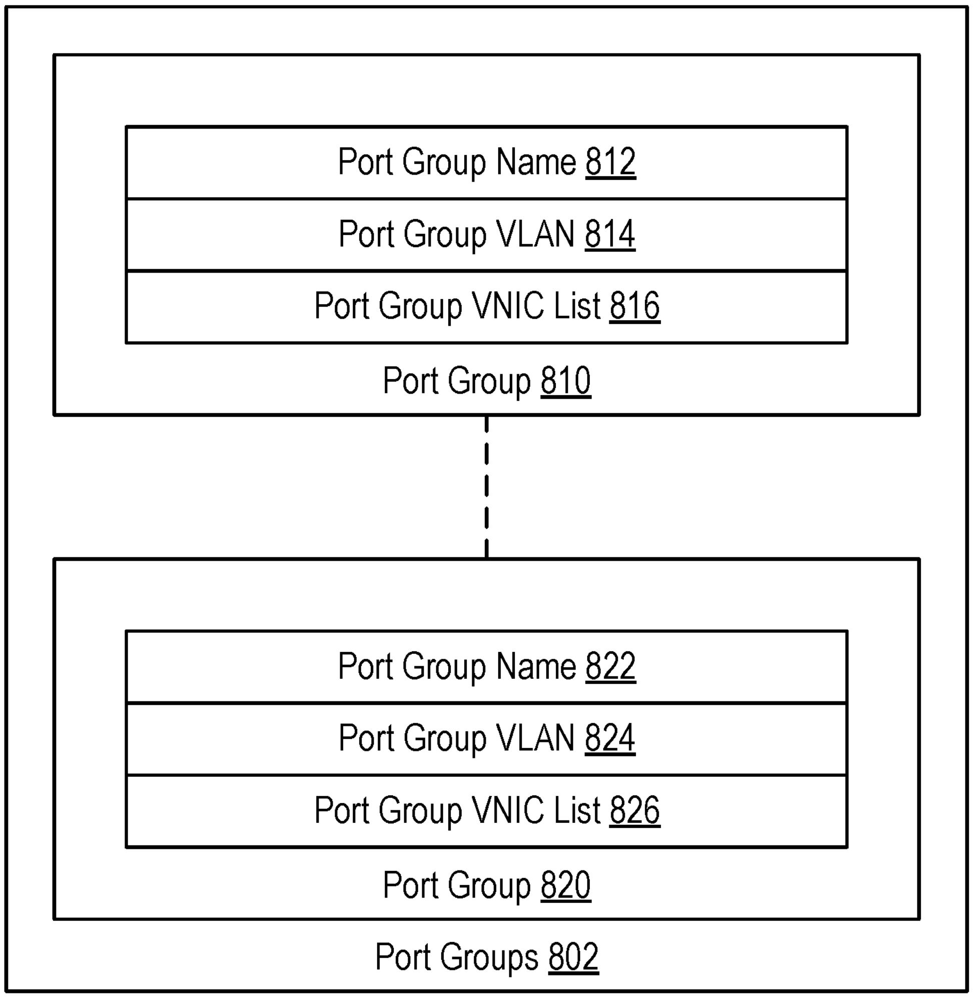

Port Group Name 812
Port Group VLAN 814
Port Group VNIC List 816
Port Group 810
Port Group Name 822
Port Group VLAN 824
Port Group VNIC List 826
Port Group 820
Port Groups 802

FIG. 9

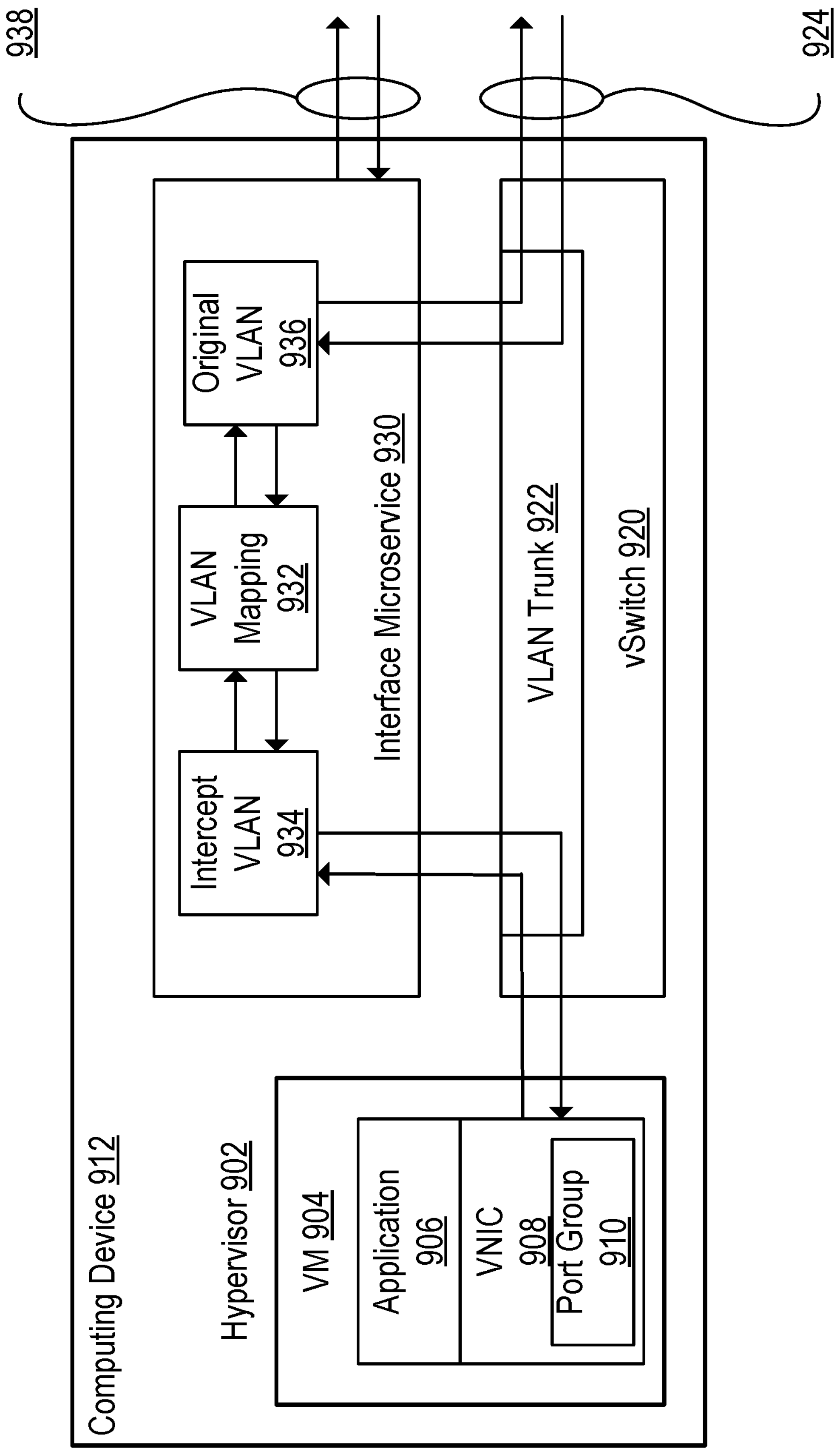

938
924
Original VLAN 936
VLAN Mapping 932
Intercept VLAN 934
Interface Microservice 930
VLAN Trunk 922
vSwitch 920
Computing Device 912
Hypervisor 902
VM 904
Application 906
VNIC 908
Port Group 910

FIG. 10A

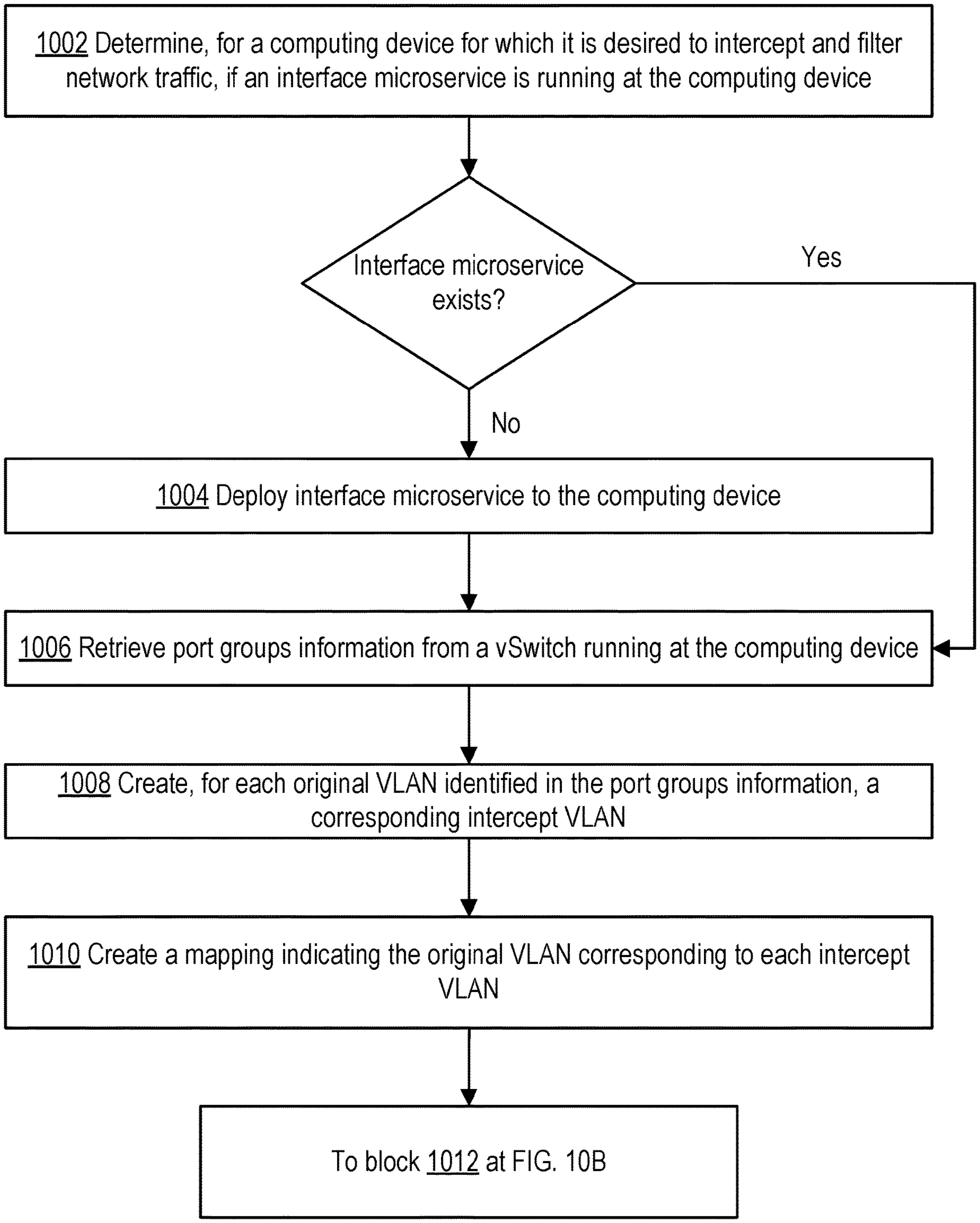

1002 Determine, for a computing device for which it is desired to intercept and filter network traffic, if an interface microservice is running at the computing device
Interface microservice exists?
Yes
No
1004 Deploy interface microservice to the computing device
1006 Retrieve port groups information from a vSwitch running at the computing device
1008 Create, for each original VLAN identified in the port groups information, a corresponding intercept VLAN
1010 Create a mapping indicating the original VLAN corresponding to each intercept VLAN
To block 1012 at FIG. 10B

FIG. 10B

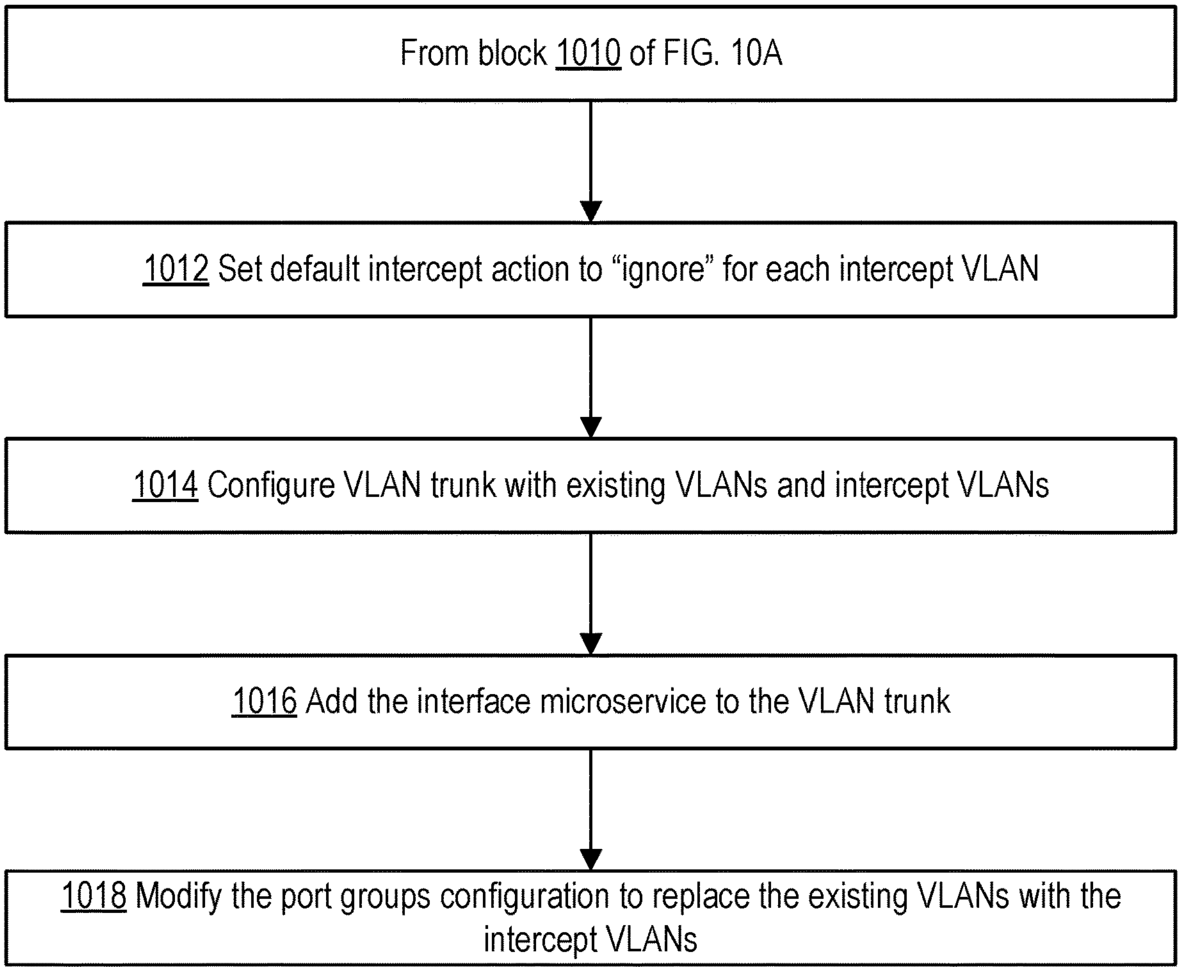

From block 1010 of FIG. 10A
1012 Set default intercept action to "ignore" for each intercept VLAN
1014 Configure VLAN trunk with existing VLANs and intercept VLANs
1016 Add the interface microservice to the VLAN trunk
1018 Modify the port groups configuration to replace the existing VLANs with the intercept VLANs

FIG. 11

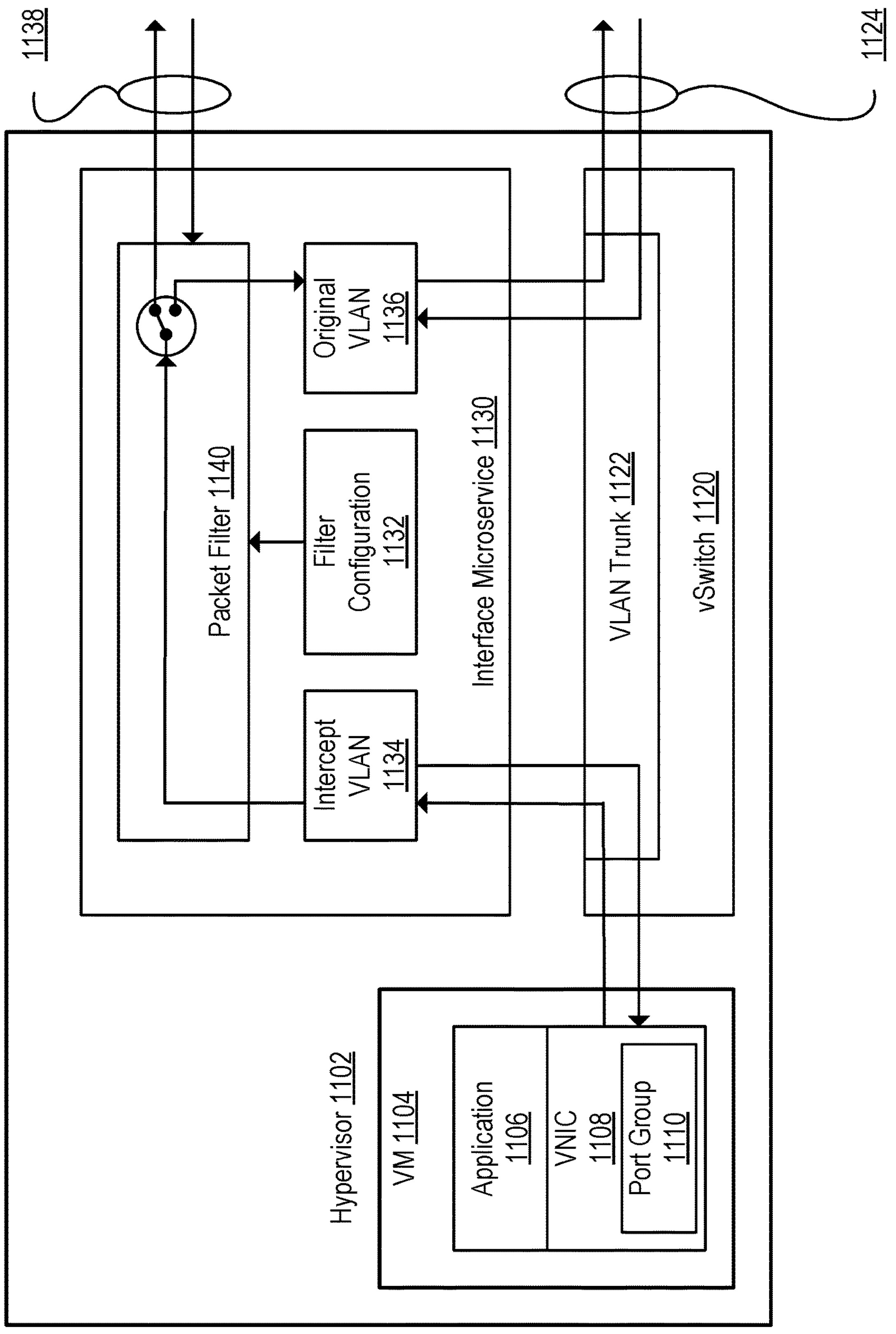

1138
1124
Packet Filter 1140
Original VLAN 1136
Filter Configuration 1132
Intercept VLAN 1134
Interface Microservice 1130
VLAN Trunk 1122
vSwitch 1120
Hypervisor 1102
VM 1104
Application 1106
VNIC 1108
Port Group 1110

FIG. 12

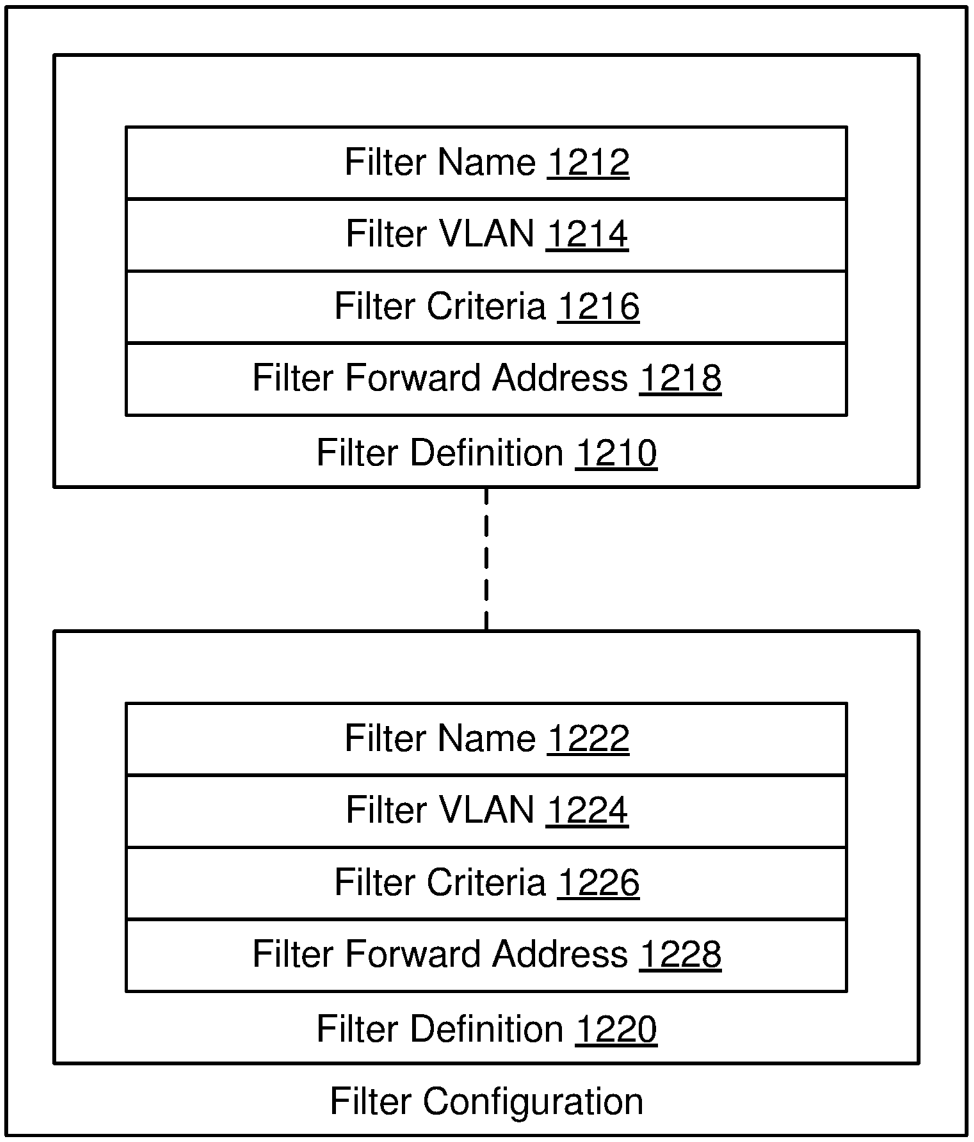

Filter Name 1212
Filter VLAN 1214
Filter Criteria 1216
Filter Forward Address 1218
Filter Definition 1210
Filter Name 1222
Filter VLAN 1224
Filter Criteria 1226
Filter Forward Address 1228
Filter Definition 1220
Filter Configuration

FIG. 13

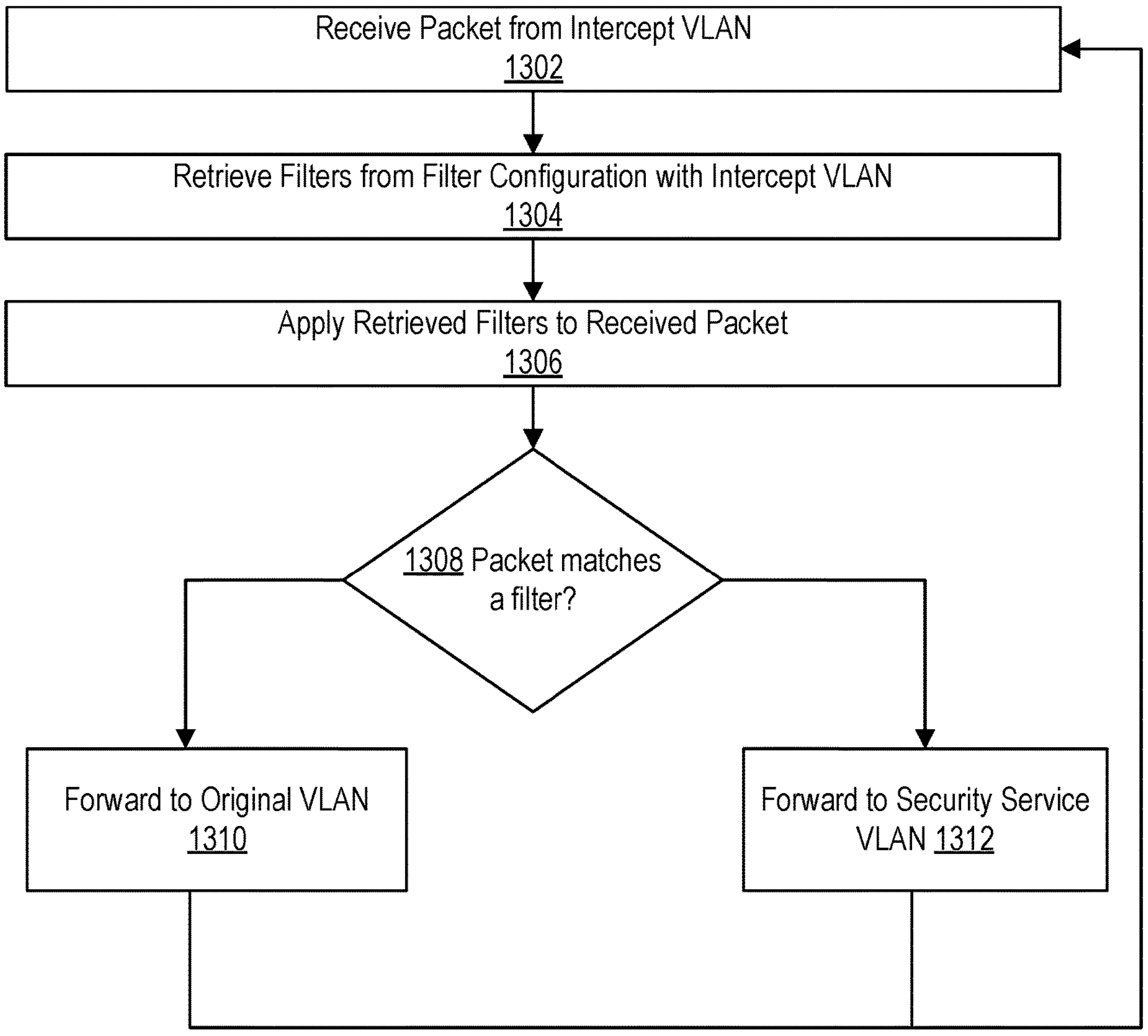
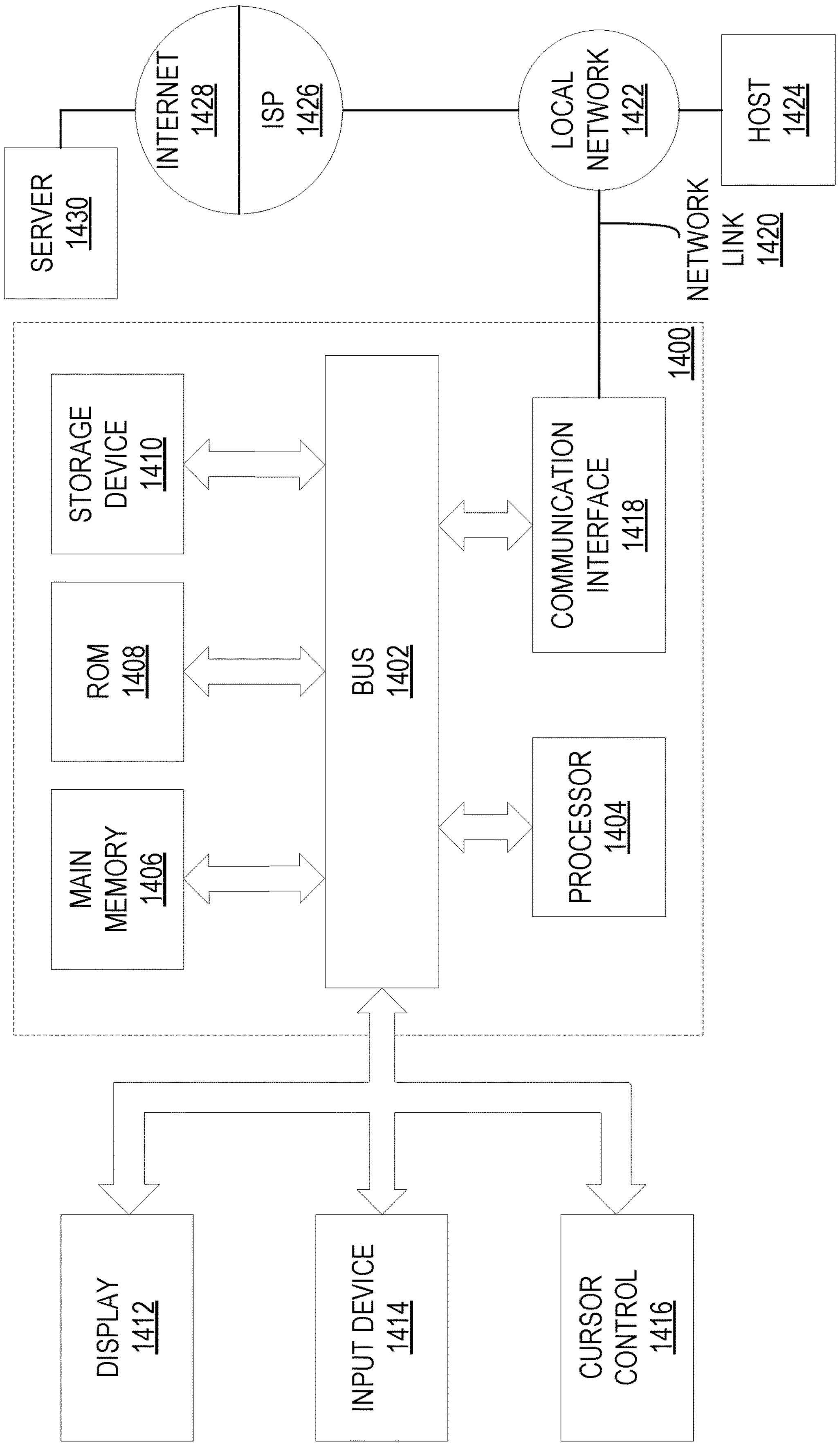

Receive Packet from Intercept VLAN 1302
Retrieve Filters from Filter Configuration with Intercept VLAN 1304
Apply Retrieved Filters to Received Packet 1306
1308 Packet matches a filter?
Forward to Original VLAN 1310
Forward to Security Service VLAN 1312

FIG. 14


SERVER 1430
INTERNET 1428
ISP 1426
LOCAL NETWORK 1422
HOST 1424
NETWORK LINK 1420
1400
STORAGE DEVICE 1410
ROM 1408
MAIN MEMORY 1406
BUS 1402
COMMUNICATION INTERFACE 1418
PROCESSOR 1404
DISPLAY 1412
INPUT DEVICE 1414
CURSOR CONTROL 1416

INTERCEPTING NETWORK TRAFFIC ROUTED BY VIRTUAL SWITCHES FOR SELECTIVE SECURITY PROCESSING

TECHNICAL FIELD

Embodiments relate generally to computer network security. More specifically, embodiments relate to techniques for intercepting network traffic routed by virtual switches and filtering the intercepted traffic for the selective application of security services.

BACKGROUND

The approaches described in this section are approaches that could be pursued, but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be assumed that any of the approaches described in this section qualify as prior art merely by their inclusion in this section.

The vast majority of organizations today rely on computer systems and networks for an increasingly wide variety of business operations. As the reliance on these systems and networks has grown, so too has the importance of securing those computer systems and networks against internal and external security threats. However, the breadth and complexity of security threats targeting such computer systems and networks is far and wide and ever growing. To monitor and address these security threats, organizations increasingly rely on sophisticated computer network security applications and hardware such as firewalls, anti-virus tools, data loss prevention software, etc.

One aspect of a network security application often involves monitoring and performing security operations on network traffic generated by monitored components of a computing environment. For example, a security application might use deep packet inspection (DPI) operations, data loss prevention (DLP) operations, and other services to analyze network traffic for the presence of potential security threats. In computing environments which include virtualized computing resources, for example, the network traffic to be monitored can include traffic generated by virtual machines (VMs) and applications running thereon.

Computing environments including VMs may further include one or more virtual switches (also referred to herein as a "vSwitch"), where a vSwitch manages network traffic for some number of VMs connected to virtualized ports of the vSwitch and forming one or more virtual local area networks (VLANs). The configuration of vSwitch can also include port groups, where a port group is a logical grouping of vSwitch ports (and by extension the VMs connected to those ports). Furthermore, port groups of a vSwitch can be assigned a trunk group, where a trunk group merges a group of virtual network links into a single logical link and can enable VLANs to span across different vSwitches.

While the ability to assign vSwitch ports to port groups and trunk groups can enable efficiencies in managing network traffic at the vSwitch, these configurations also present challenges for examining traffic routed by a vSwitch for security purposes. For example, assume a web application running on a first VM accesses a SQL server running on a second VM accessible via a network routed by a vSwitch. In this example, a network administrator might desire to monitor and perform security operations on network traffic sent by the VM to the SQL server (e.g., for possible instances of SQL injection attacks or other database-related threats), but to ignore other types of network traffic sent from the VM and

from other VMs on a same VLAN. If the VLAN is assigned to a trunk group (where the links of the trunk group are treated a single logical link), then a security application can perform such security processing by routing the trunk group traffic through the security application. However, performing security processing on the trunk group traffic can involve processing a significant amount of traffic from other VMs and applications which are irrelevant to the SQL traffic for the VM of interest.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a block diagram illustrating computer hardware for loading network security system microservices from a memory and executing them by a processor in accordance with the disclosed embodiments;

FIG. **2** illustrates a scalable security architecture implementing a three-time scale out using security microservices in accordance with the disclosed embodiments;

FIG. **3** illustrates an arbitrary scaling out of a microservice in accordance with the disclosed embodiments;

FIG. **4** is a block diagram illustrating a security service configured to monitor traffic sent among an application and one or more servers through a routing network in accordance with the disclosed embodiments;

FIG. **5** is a block flow diagram illustrating application data traversing to a server after passing through a hierarchy of a security microservices in accordance with the disclosed embodiments;

FIG. **6** is a flow of application data through a stateless processing, fault-tolerant microservice environment in accordance with the disclosed embodiments;

FIG. **7** is a block diagram illustrating an example computing device running at least one virtual machine (VM) coupled to a routed network via a virtual switch (vSwitch) in accordance with the disclosed embodiments;

FIG. **8** is a block diagram illustrating example port group settings in accordance with the disclosed embodiments;

FIG. **9** is a block diagram illustrating an example computing device including an interface microservice configured to intercept network traffic routed through a vSwitch in accordance with the disclosed embodiments;

FIGS. **10**A, **10**B include a flow diagram illustrating an example method for configuring an interface microservice to intercept network traffic routed by a vSwitch in accordance with the disclosed embodiments;

FIG. **11** is a block diagram illustrating an example computing device including an interface microservice configured to intercept and filter network traffic routed by a vSwitch in accordance with the disclosed embodiments;

FIG. **12** is a block diagram illustrating example filter definitions in accordance with the disclosed embodiments;

FIG. **13** is a flow diagram illustrating an example method used to filter network traffic routed by a vSwitch and intercepted by an interface microservice in accordance with the disclosed embodiments; and

FIG. **14** illustrates a computer system upon which an embodiment may be implemented.

DETAILED DESCRIPTION

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of embodiments of the present invention. It will be apparent, however, that embodiments of the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form to avoid unnecessarily obscuring embodiments of the present invention.

References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment need not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

Embodiments are described herein according to the following outline:

1.0. General Overview

Modern data centers and other computing environments can include anywhere from a few computer systems to thousands of systems configured to process data, service requests from remote clients and other applications, and perform numerous other computational tasks. The large number of interworking systems, applications, etc., make such computing environments susceptible to a wide variety of network security threats and other issues. A number of network security tools are available to protect such systems and the computer networks interconnecting these systems, and many of these tools comprise a monolithic set of network security functions. For example, a typical network security tool might comprise a hardware unit including firewall services, routing services, virtual private network (VPN) services, and so forth.

The type of network security tool described above is useful for providing a variety of network security functions as a single unit. However, efficiently scaling these types of network security tools is often challenging. For example, if a particular computer environment might benefit from increased firewall resources, a system administrator may install one or more additional hardware units each including firewall services in addition to a suite of other network security functions. While the addition of these new hardware units may meet the increased firewall resource needs, some of the hardware units may include unnecessary and/or underutilized resources devoted to virtual private network (VPN) services, data loss prevention (DLP) services, or other security services.

One way in which many modern computing environments scale resources more efficiently is using virtualized computing resources. A virtualized computing resource generally refers to an abstracted physical computing resource presented to an operating system and its applications by means of a hypervisor, such that the virtual computing resources (compute, memory, network connectivity, storage, etc.) are configurable and may be different from those of the physical computing resource. According to one embodiment, these types of virtualized infrastructures are used to efficiently scale network security applications based on the use of "microservices," where a microservice is a particular type of virtualized computing resource packaged as a software container. For example, a network security platform may comprise separate microservices providing firewall resources, DLP services, VPN services, etc. In general, the use of such microservices can provide greater flexibility because the microservices can be more easily deployed and scaled in response to variable demands for various types of network security services.

The type of efficient network security application scaling described above can be achieved with the use of a security application that is configured to scale network security services using microservices. Although many of the techniques described herein are explained with reference to a microservice-based network security application, the techniques are also applicable to other types of network security systems.

2.0. Operating Environment

2.1. System Overview

FIG. **1** is a block diagram illustrating an embodiment of a scalable microservice architecture using microservices. Network security system microservices **108-122** are stored in memory **104** (e.g., volatile memory such as Random Access Memory (RAM) and/or non-volatile memory such as disk) and executed by one or more hardware processors or processor cores **102**. Network security system microservices **108-122**, consisting of computer-executable instructions to perform one or more specific security services, are deployed based on configuration across available physical servers. Typically, each microservice receives a configuration and tasks via a backplane of a virtual chassis **106**, and returns status, statistics, and other information to the backplane.

The data processed by the network security system **100** is transferred from a microservice to another (higher hierarchy) microservice using a data plane. In some embodiments, during such a transfer, a lower microservice decides (based on configuration, current statistics, and other information) as to which next microservice to utilize. Such a decision may constitute a load-balancing decision to assure that the higher-hierarchy microservices are efficiently utilized. In other embodiments, the decision of which microservice to utilize is made by a more central entity.

As illustrated, a network security system **100** utilizes a hardware processor **102** (such as a central processing unit (CPU) or one or more cores thereof, a graphics processing unit (GPU) or one or more cores thereof, or an accelerated processing unit (APU) or one or more cores thereof) to execute microservices stored in memory **104**. A network interface **128** (e.g., fabric or interconnect that is wired or wireless) provides a means for communicating with a data center. Network security system **100** may inspect traffic, detect threats, and otherwise protects a data center using the microservices **108-122**.

Embodiments of a network security system **100** providing the above capabilities are now discussed in more detail. Network security system **100** adds security to, or enhances the security of, a datacenter or other computing environment. In an embodiment, network security system **100** is delivered (e.g., downloaded) in the form of a seed software application. The seed software application instantiates microservices of the network security system on a host in the datacenter. As used herein, a microservice container refers to where the microservice runs, for example, on a virtual machine. Once deployed, network security system **100** utilizes a hardware processor **102**, memory **104**, and network interface **128**. In many scenarios, security can be added/configured using existing hardware and/or without purchasing additional rack devices for particular functionality. The seed software application may be installed on any one of a wide variety of hosts—be they slow or fast, low-cost or high-cost, commodity or customized, geographically dispersed, part of a redundancy scheme, or part of a system with regular back-ups.

In some embodiments, a network security system **100** utilizes a network interface **128** to explore the datacenter and to discover existing network segments, determine security settings to apply to various network segments, detect available hosts and hardware resources, and determine additional configuration information as needed. In an embodiment, the datacenter itself includes several machines with hypervisors, or physical hardware, and the network security system **100** offers microservices to communicate with and protect one or more of those internal virtual machines or physical hardware. Based on performing datacenter discovery, a network security system **100**, in some embodiments, may then offer or suggest available security tools for selection either through a graphical interface or via connections with existing enterprise management software. In one embodiment, once configured, a network security system **100** is deployed "in-line," receiving packets headed for the datacenter, thereby allowing network security system to intercept and block suspicious traffic before it reaches the datacenter. With an understanding of the datacenter, a network security system **100** deploys microservices to inspect traffic throughout the datacenter, and not only at ingress. In some embodiments, a network security system **100** is deployed in a "copy only" configuration, in which the system monitors traffic, detects threats, and generates alerts, but does not intercept traffic before it arrives at the datacenter.

As shown, memory **104** has stored therein microservices **108**, **110**, **112**, **114**, **116**, **118**, **120**, and **122** (**108**-**122**), as well as a virtual chassis **106**, which is also a microservice. In an embodiment, the microservices are small in size, consisting of a relatively small number of instructions. In an embodiment, the microservices **108**-**122** are independent of each other. As illustrated, microservices **108**-**122** are microservices that are loaded from memory and executed by the hardware processor **102**. Those microservices **108**-**122** include data path security microservices, for example TCP/IP, SSL, DPI, or DLP microservices, as described further below with respect to FIGS. **2** and **3**. The microservices **108**-**122** may also include management microservices, for example, a chassis controller to manage the microservices, a configuration microservice, an infrastructure discovery microservice, a database microservice to store data, a policy update microservice to receive policy updates from an external security cloud, and a compiler to receive policy data from various sources and to produce binary policy outputs to be used by the microservices, to name a few examples that are described hereinafter with respect to FIGS. **2** and **3**.

In an embodiment, a network security system **100** receives traffic via network interface **128** to/from a datacenter. In one embodiment, a network security system **100** is placed in-line to inspect traffic, and potentially intercept a threat before it arrives at, or leaves, the datacenter. In other embodiments, a network security system **100** monitors the traffic heading into, or out of, the datacenter, in which case the network security system **100** detects threats and generates alerts, but does not block the data. A hardware processor **102** may execute various data security microservices on the data. For example, as described hereinafter with respect to FIGS. **2** and **3**, typically traffic first passes into and through a segment microservice, then a TCP/IP inspection microservice, then a SSL microservice, then a DPI microservice, then a NOX microservice, and then a DLP microservice. However, one or more of these services may not be enabled. In some embodiments, a segment microservice resides within a network segment and serves as the entry point for data packets and forwards the packets to appropriate microservices for further analysis. Data path microservices as used herein refer to various microservices that inspect and analyze network traffic, such as TCP, TLS, DPI, NOX, and DLP microservices. A TCP microservice, for example, refers to a packet handling microservice able to process any layer 4-6 network packet and includes part of firewalling. A TLS microservice, for example, refers to a Transport Layer Security microservice, which decrypts/re-encrypts connections. A DPI microservice, for example, refers to a Deep Packet Inspection microservice and handles layer 7 inspection. A NOX microservice, for example, refers to a Network Object Extractor microservice, and works in conjunction with DPI to assemble objects from individual packets and to deliver the objects to other services. A DLP microservice, for example, refers to a Data Loss Prevention microservice, which detects and attempts to prevent data loss. Control path microservices, on the other hand, are various microservices, such as a factory, a compiler, a configuration, an infrastructure discovery, a database, a messenger, a scaler, and a chassis controller, that are instantiated in, and make up, a management plane. Threats detected by the aforementioned microservices, in one embodiment, are reported to a chassis controller microservice, which takes remedial action.

In an embodiment, microservices **108**-**122** are implemented using computer-executable instructions loaded from the Internet via network interface **128**. For instance, in an embodiment, the microservices are implemented with computer-executable instructions downloaded from a web site or online store site. In some embodiments, microservices **108**-**122** are loaded into memory **104**. In various embodiments, the microservices are implemented using computer-executable instructions loaded on and received from a non-transitory computer readable medium, such as digital media, including another disc drive, a CD, a CDROM, a DVD, a USB flash drives, a Flash memory, a Secure Digital (SD) memory card, a memory card, without limitation. Microservices received from a digital medium may be stored into memory **104**. The embodiments are not limited in this context. In further embodiments, a digital medium is a data source that constitutes a combination of hardware elements such as a processor and memory.

In most embodiments, a network security system **100** runs on a datacenter computer. In other embodiments, however, a network security system **100** is installed and runs on any one of a wide variety of computing platforms, ranging from low-cost to high-cost, and from low-power to high power. In some embodiments, a network security system **100** runs on a server. In some embodiments, a network security system **100** is installed on and runs on a low-cost, commodity server computer, or on a low-cost rack-mounted server. As illustrated, hardware processor **102** is a single core processor. In alternate embodiments, hardware processor **102** is a multi-core processor. In alternate embodiments, hardware processor **102** is a massively parallel processor. In some embodiments, a virtual chassis **106** and microservices **108**-**122** may be hosted on any of a wide variety of hardware platforms used in the datacenter to be protected.

In some embodiments, a network security system **100** scales out using available resources to accommodate higher traffic or load. In one embodiment, hardware processor **102** (CPU) and memory **104** are scaled out or in dynamically as needed: additional CPUs and memory are added if scaling out, and some CPUs and/or memory are powered down if scaling in. This scaling out is performed to allocate the additional CPUs and memory to those portions of the security hierarchy for which there is demand, while not allocating additional CPUs and memory to those portions of the security hierarchy that can accommodate the higher traffic utilizing their existing allocation.

One property of a microservice is the separation and protection of memory from other microservices. In this manner, an individual microservice may be moved to another physical server or terminate abnormally without impacting other microservices. Microservices may be distinguished from threads in that threads generally operate within a shared memory space and exist within the confines of an operating system on which the microservices were spawned.

FIG. **2** illustrates an example scalable security architecture implementing a three-time scale out using security microservices. In the example of FIG. **2**, only a single microservice (e.g., a DPI microservice) has a demand for additional resources. As shown, by utilizing a scalable microservice architecture **200**, including DLP microservice **204**, NOX microservice **206**, DPI microservice **208**, SSL/TLS microservice **210**, TCP/IP microservice **212**, and segment microservice **214**, each layer of the security service hierarchy can be scaled and configured independently to load balance the supply of processed data to the next hierarchy level. As shown, datacenter **216** includes datacenter rack **218**, which includes physical server A **220**, physical server B **222**, and physical server C **224**. As shown, a datacenter rack **226** includes physical server X **228**, physical server Y **230**, and physical server Z **232**. DPI microservices **208** have been scaled out 3×, and in this instance assigned to be performed as microservices 4-to-6 on physical server B **222** and physical server C **224**. The remaining microservices of scalable security architecture are shown as being implemented by physical servers A, X, Y, and Z (**220**, **228**, **230**, and **232**, respectively). A configuration microservice **202** creates a configuration backplane and a data plane deployed as a software component on each physical server that is to receive security services. This process includes configuring routing rules, reserving network address space (such as a subnet), and configuring virtual environments to utilize portions of the reserved address space as gateways for network communication in and out of the servers to be secured. Both the backplane and data plane may thus be considered virtual networks managed by the security system. Security microservices may then utilize these networks to transmit packets, content, state, and other information among the microservices. The properties of the backplane and data plane are configured to reject packet traffic from outside the security system and to route information between microservices regardless of the physical server and virtual environment configuration.

FIG. **3** illustrates an arbitrary scaling out of a microservice according to an embodiment. As shown, scalable security architecture **300** includes configuration microservice **302**, DLP (2×) microservice **304** (a 2-times scale-out), NOX microservice **306**, DPI (3×) microservice **308** (a 3-times scale-out), SSL/TLS microservice **310**, TCP/IP (3×) microservice **312** (a 3-times scale-out), and segment microservice **314**. As shown, configuration microservice **316** provisions

(**318**, **320**, **322**, **324**, **326**, and **328**) the 11 microservices from a lowest hierarchy to a highest hierarchy, and configures them to communicate with each other via a backplane. The microservices, for example, may be implemented by physical servers in datacenter **330**.

FIG. **4** is a block diagram illustrating a networked computing environment in which an embodiment may be implemented. FIG. **4** represents an example embodiment that is provided for purposes of illustrating a clear example; other embodiments may use different arrangements.

The networked computer system depicted in FIG. **4** comprises one or more computing devices. These one or more computing devices comprise any combination of hardware and software configured to implement the various logical components described herein. For example, the one or more computing devices may include one or more memories storing instructions for implementing the various components described herein, one or more hardware processors configured to execute the instructions stored in the one or more memories, and various data repositories in the one or more memories for storing data structures utilized and manipulated by the various components.

In one embodiment, one or more security services **410** may be configured to monitor network traffic and other data sent between an application **416** and one or more servers **404**, **406** through a routing network **408**. The security service **410** comprises one or more "microservices" used to monitor and perform various actions relative to data items (e.g. network traffic, files, email messages, etc.) sent to and received from one or more applications **416** and servers **404**, **406**. The microservices comprising security service **410** may not be confined to one physical server such as a server **404**, **406**. For example, one or more microservices of the security service **410** may be executed on server **404**, and other microservices of the security service **410** may be executed on server **406**. In some embodiments, the security service **410** is executed on a different server from one or more servers for which the security service is responsible for monitoring and protecting.

In an embodiment, a routing network **408** provides connectivity among servers **404**, **406**, security service **410**, and application **416**. In some embodiments, routing network **408** is partially configured responsive to hypervisor configuration of servers **404** and **406**. In some embodiments, a routing network **408** is partially or entirely configured responsive to hypervisor configuration of servers **404** and/or **406**.

In one embodiment, by virtue of routing information included in channel data encapsulation packets, data traveling between an application **416** and server **404** and/or server **406** is routed to the correct server, and is kept separate from data traveling between the application **416** and the other server. Accordingly, what is essentially a private network **412** may be created between the server running security service **410** and server **404**. Similarly, what is essentially a private network **414** may be created between the server running security service **410** and server **406**.

FIG. **5** is a block flow diagram illustrating application data traversing to a server after passing through a hierarchy of a security microservices according to an embodiment. As illustrated, the flow begins with security service **504** receiving a network data packet from application **502**. Security service **504** forwards **506** the packet to interface microservice **508**, which generates a channel data encapsulation packet **510** encapsulating three packets A, B, and C, and a context X. As shown, channel data encapsulation packet **510** encapsulates three packets, but in alternate embodiments, the number of encapsulated packets may vary without limitation. In some embodiments, context X is generated based at least on the headers of packets A, B, and C. In some embodiments, context X is generated based on a lookup of packet header fields such as Internet Protocol (IP) addresses, ports, and MAC addresses for the source and/or destination of the packets. In some embodiments, the generation of context X includes using an interface identifier obtained from a virtualization environment. Generation of context X may be accomplished through a lookup of header fields and other data in a table, a hash of header fields and other data, or another method whereby packets for which a common security policy is to be applied are associated with a common context or common portion, such as a bit field, of the context.

Context X may be considered an identifier describing the traffic streams, source machines, or applications responsible for generating packets A, B and C. This identifier may be direct (such as an ID used as a table look up), indirect (such as a pointer used to access a data structure), or some other method of instructing microservices as to the policies and processing to use for handling packets A, B, and C. As an example, context X may be generated by performing a hash, longest prefix match, or lookup of header fields such as IP addresses, TCP ports, interface names (or MAC addresses), or other packet properties. The lookup may be an exact match, longest prefix match, or other method to associate packet streams with the same security processing to use. The generated context may then be used by security services, such as a DPI service, to determine which rules to utilize when scanning the data from packets A, B, and C (and other packets that are part of the same traffic stream). This information may be embedded within the context (as a bit field or other information), available by indirection (such as a table or data structure lookup by another service), or generated programmatically based on any combination of such information.

The context may be generated through a look up at an interface microservice and is included in the transmission of packet data to transmission control protocol (TCP) reassembly services. Reassembled content from the TCP microservice is transmitted to a deep packet inspection (DPI) microservice or secure socket layer (SSL) microservice, and with the same context. By maintaining this context in the encapsulation of data transport throughout the microservice hierarchy, processing directives associated with a context become a shared read-only resource (relative to the microservices) and may only rarely use stateful updates.

Interface microservice **508** transmits **512** the channel data encapsulation packet **510** to TCP/IP microservice **514**. As shown, the channel data encapsulation packet **516** includes context X and content Y, which corresponds to packets A, B, and C of channel data encapsulation packet **510**. After conducting security processing of the channel data encapsulation packet **516**, TCP/IP microservice **514** transmits **518** the packet to DPI microservice **520**. As shown, the channel data encapsulation packet **522** includes context X and content Y, which corresponds to packets A, B, and C of channel data encapsulation packet **510**. After conducting security processing of the channel data encapsulation packet **522**, DPI microservice **520** generates channel data encapsulation packet **24**, which, as shown, includes context X, DPI load Z, and DPI timestamp T. Encapsulated channel data may be tagged with properties including a timestamp and a load metric. The timestamp may reference the duration of microservice processing, the time at which microservice processing started or another temporal property associated with processing the encapsulated channel data. The load metric may reference the relative or absolute loading of a microservice processing the encapsulated channel data.

As shown, a DPI microservice **520** transmits, via path **526**, channel data encapsulation packet **524** to TCP/IP microservice **514**, which uses the DPI load and DPI timestamp information to inform future load-balancing decisions. As shown, a TCP/IP microservice **514** generates channel data encapsulation packet **528**, which includes context X, TCP/IP load Z, and TCP/IP timestamp T. As shown, TCP/IP microservice **514** transmits, via path **530**, channel data encapsulation packet **528** to interface microservice **508**, which uses the TCP/IP load and TCP/IP timestamp information to inform future load-balancing decisions. The flow is completed when interface microservice **508** transmits, via path **532**, packets to security service **504**, which transmits the packets to a server **534**.

As shown, DPI microservice **520** transmits channel data encapsulation packet **524** to TCP/IP microservice **514**, which uses the DPI load and DPI timestamp information to inform future load-balancing decisions. As shown, TCP/IP microservice **514** generates channel data encapsulation packet **528**, which includes context X, TCP/IP load Z, and TCP/IP timestamp T. As shown, TCP/IP microservice **514** transmits channel data encapsulation packet **528** to interface microservice **508**, which uses the TCP/IP load and TCP/IP timestamp information to inform future load-balancing decisions. The flow is completed when interface microservice **508** transmits, via path **532**, packets to security service **504**, which transmits them to server **534** microservice.

Exemplary benefits of the security service **504** may include the ability of each microservice to utilize the same channel data encapsulation protocol for all communication, thereby allowing scaling across the entirety of the datacenter network routable via the channel data encapsulation header. Communications between microservices maintain a context X generated at interface microservice **508** to all subsequent microservices that no longer have access to the original packets. As an example, a DPI microservice processing content reassembled by a TCP/IP microservice has no visibility into the packets used by the TCP/IP microservice to reassemble the content. However, the context X generated upon reception of one or more of those packets at the interface microservice, forwarded to the TCP/IP microservice and subsequently forwarded by the TCP/IP microservice to the DPI microservice, may be used to determine policy or select a minimal DPI signature set by the DPI microservice without incurring additional state processing. By providing load and timestamp data in the channel data encapsulation packets **524** and **528**, which are returned via paths **526** and **530**, the microservices receive and can maintain real-time loading and processing latency information utilized to make load balancing decisions.

FIG. **6** is a block diagram illustrating a flow of application data through a stateless processing, fault-tolerant microservice environment in accordance with disclosed embodiments. As illustrated, security system **600** includes interface microservices **602**, **604**, and **606**, TCP/IP microservices **610** and **612**, and DPI microservices **620**, **622**, and **624**. Other examples include a different number of microservices and/or a different number of microservice types. In the example of FIG. **6**, an interface microservice **602** receives packet A **608**, and generates a context X **660**.

One benefit of the security system illustrated in FIG. **6** is the handling of state. For example, if packets belong to a certain context X, the security system **600** may enable both TCP/IP microservices **610** and **612** to perform meaningful work on the packets. By implementing TCP/IP processing as microservices **610** and **612** with an external state structure and a context that accompanies processed data, each TCP/IP microservice, and any other microservice at every level of the security hierarchy, can be isolated from other microservices and can be scaled independently. Each microservice can access the state for any packet or reassembled packet data, thereby enabling real-time load balancing. In many cases, the context enables microservices to forego consulting service state (state associated with processing at the hierarchy level of the specific microservice), thereby reducing the demands on the global state repository.

As an example, consider the context X **662** obtained by TCP/IP microservice **610** as part of packets received from interface microservice **602** as transmission **646**. Context X **662**, when transmitted to DPI microservice **620** as part of transmission **644**, along with the reassembled packet data, contains information that may enable the DPI microservice to forego or simplify processing of this reassembled data. Such information can include, for example, a context bit or field specifying a subset of regular expressions or patterns to be used for DPI processing, a number of bytes of reassembled data to be received before beginning DPI processing, specific allowed or disallowed protocols, and other information potentially avoiding a DPI state lookup.

In an embodiment, microservices of a security system **600** are stateless. For example, each of the microservices may retrieve state information from an outside source such that the microservice can process packets or content belonging to any context. Each microservice may retrieve and update service state (that state associated with the microservice processing). Additionally, each microservice may retrieve and update context state (state associated with the context relevant for all security service processing). In some embodiments, the process state and context state share a global state service. Examples of elements of context state include a level of suspicion regarding traffic from a source IP, a policy to ignore certain ports or protocols, and other information used to process the packets, reassembled content, and extracted objects from communication identified with the context.

In an embodiment, multiple microservices in the same or different hierarchy of the security system may be able to process packets associated with the same context at the same time. If one security microservice fails (e.g., if a TCP microservice fails to respond to a request), another microservice can take over and process the request using the failed microservice's context.

Returning to FIG. **6**, the generation of context X **660** may include considering properties associated with a packet A **608** (e.g., such as an n-tuple detailing routing information), and also a state lookup or a context lookup, in addition to other information. Interface microservice **602** provides packet A **608** and context X **660** to TCP/IP microservice **610** or **612** via path **640** or **650**, respectively. For example, interface microservice **602** may conduct a load-balancing to select one of the TCP/IP microservices to forward the packet A **608** and the context X **660**.

In an embodiment, TCP/IP microservices **610** and **612** are stateless, but may benefit from the context X generation performed by interface microservice **602**. For example, whichever of TCP/IP microservices **610** and **612** receives packet A may disassemble the packet to extract the data associated with the packet and conduct security processing on the data. TCP/IP reassembly generally consists of associating packets with flows (e.g., identified by source and destination IP and port values) and using the TCP sequence

numbering to place the packets into a correct order, remove any overlap or duplication, and/or identify missing or out of order packets.

In FIG. **6**, TCP/IP microservices **610** or **612** forward the extracted data and/or the data resulting from the security processing to DPI microservice **620** via paths **644** or **656**, respectively. Along with the transmitted data, TCP/IP microservice **610** or **612** forwards context X **662** or **664**, respectively, to a DPI microservice **620**. In some embodiments, context X **660**, **662**, **664**, and **666** are substantially identical.

In an embodiment, DPI microservice **620** is also stateless and may use the context provided by TCP/IP microservice **610** or **612** in transmission **644** or **656**. DPI microservice **620** may load DPI processing state before processing the received data, but can perform some work (e.g., scheduling different DPI pattern state tables) based on the context. Transmitting the context to the DPI microservice therefore may obviate some amount of work by the DPI microservice. If TCP/IP microservice **610** fails and interface microservice **602** instead utilizes TCP/IP microservice **612**, DPI microservice **620** may obtain the context from the transmission of reassembled TCP content in transmission **656**.

Although FIG. **6** does not show a second packet, when a subsequent packet associated with the same context is received, interface microservice **602** may conduct a load balancing and select one of the TCP/IP microservices to forward the packet along with context X **660**. In one embodiment, interface microservice **602** chooses to forward the second packet to TCP/IP microservice **612** via path **650**. TCP/IP microservice **612** performs some security processing, then transmits the second packet and context X **664** to DPI microservice **620** via path **654**. After performing some security processing, DPI microservice **620** responds to TCP/IP microservice **612** via path **654**, and TCP/IP microservice responds to interface microservice **602** via path **656**.

Summarizing the operation of an embodiment as illustrated by FIG. **6**, an interface microservice transmits packets to a TCP/IP microservice along with a context that has been generated based on the contents of the packets. The transmission comprises a request to perform a security service (e.g., TCP/IP reassembly) for the packets to generate reassembled data. The TCP/IP microservice consults the received context to determine whether to obtain a context state, service state, or both, from a state repository to perform the security service. Reassembly is performed by the TCP/IP microservice, any modified state returned to the state repository and the reassembled data transmitted, along with the context, to a DPI microservice as a request to perform DPI processing.

Continuing the example illustrated by FIG. **6**, the DPI microservice receives the reassembled data and context from the request to perform DPI security services transmitted by the TCP/IP microservice. The DPI microservice consults the received context to determine whether to obtain a context state, service state, or both, from a state repository to perform its security service. DPI inspection may be performed by the DPI microservice, any modified state returned to the state repository, and a response sent to the TCP/IP microservice.

2.2. Microservices for Intercepting Network Traffic

FIG. **7** is a block diagram illustrating an example system for using an interface microservice to intercept network traffic routed by a virtual switch (vSwitch). In an embodiment, a system **700** includes at least one computing device

712 coupled to at least one other computing device **714** via a routed and/or switched network **740**. The routed and/or switched network **740**, for example, might be a network within a data center interconnecting various types of devices within the data center, or any other type of network connecting computing devices **712**, **714**. FIG. **7** represents an example embodiment that is provided for purposes of illustrating a clear example; other embodiments may use different arrangements.

In an embodiment, a computing device **712** includes a hypervisor **702**, vSwitch **720**, and an interface microservice **730**. The hypervisor **702** is a component implemented in software, hardware, firmware, or combinations thereof, and which manages the creation and operation of one or more virtual machines (VMs) (e.g., a VM **704**). Examples of a hypervisor **702** include, but are not limited to, a VMware® ESX™/ESXi™ hypervisor, a Citrix® XenServer® hypervisor, or a Microsoft® Hyper-V® hypervisor. In some embodiments, vSwitch **720** and port groups **722** are integrated into or otherwise part of hypervisor **702**, configured via hypervisor **702**, or some combination thereof.

In an embodiment, a VM **704** running on a hypervisor **702** is generally any type of emulated computer system that can share hardware resources with one or more other VMs running on the hypervisor **702**. In the example of FIG. **7**, a VM includes at least one application **706** and at least one virtual network interface card (VNIC) **708**. Examples of an application **706** include, but are not limited to, an operating system, a system application, and a user application.

In an embodiment, a VM **704** is one of a plurality of VMs networked as part of a virtual network. The plurality of VMs can be networked in part using one or more vSwitches (e.g., vSwitch **720**). Whereas a physical Ethernet switch manages network traffic between machines on a physical network, a vSwitch manages network traffic between VMs logically connected to virtual ports of the vSwitch. A vSwitch can be connected to other vSwitches and to one or more physical switches (not shown in FIG. **7**) using physical Ethernet adapters to join virtual networks with physical networks. For example, the network path **724** might connect the vSwitch **720** to a routed and/or switched network **740** via one or more physical switches.

In an embodiment, a VNIC **708** of a VM **704** is connected to a port of the vSwitch **720**, and the port can be assigned to a port group **710**. At a high level, a port group is a vSwitch configuration which defines a logical grouping of VNICs connected to the ports comprising the group. For example, a system **700** might include any number of VMs **704** having any number of VNICs **708**, and the VNICs can be grouped into any number of port groups by the vSwitch **720**. A port group can be further associated with configuration options applied to the member ports including, for example, bandwidth limitations, traffic shaping rules, and other settings. In an embodiment, a vSwitch **720** stores configuration information related to port groups as port groups configuration **722**. Based on the port groups configuration **722**, for example, when a vSwitch **720** receives a packet from a VNIC of a VM, the vSwitch **720** can determine which port group the VNIC is associated with and tag the packet with a VLAN assigned to the port group in the configuration.

FIG. **8** is a block diagram illustrating an example set of port group definitions, as shown in FIG. **7**. For example, the port groups configuration **802** shown in FIG. **8** includes the port group definitions **810**, **820**. In one embodiment, a port group definition includes a port group name (e.g., port group name **812**, **822**), a port group VLAN (e.g., port group VLAN **814**, **824**), and a port group VNIC list (e.g., port group VNIC

lists **816**, **826**). A port group name is an optional label for the port group, the port group VLAN identifies a VLAN associated with the port group, and the port group VNIC list identifies a set of VNICs belonging to the port group. The example port group configuration as shown in FIG. QAH, for example, can be part of port groups configuration **722** stored at a vSwitch **720**, as shown in FIG. **7**.

As described in more detail herein, an interface microservice **730** enables network traffic sent to and received from a VM **704** (and any other VMs generating network traffic routed by vSwitch **720**) to be intercepted and filtered based on an intercept configuration **732**. As shown in FIG. **7**, an interface microservice **730** can optionally send, via network path **734**, intercepted network traffic to a security microservice **752** running on a separate computing device **714**. The computing device **714**, for example, includes a separate hypervisor **750** and may further include any number of VMs running on the hypervisor **750**. In other examples, an interface microservice **730** can perform various security operations locally at the computing device **712** without sending the intercepted network traffic to a separate computing device **714**.

In one embodiment, a microservice as depicted in FIG. **7** (e.g., interface microservice **730** or security microservice **752**) is implemented using a software "container," where a container is an isolated user space instance within a virtualization environment in which the kernel of an operating system allows for the existence of multiple isolated user-space instances. In other examples, a microservice is implemented by a virtual machine instance, a thread of execution, a standalone software application, or any other type of computer-executable logic.

FIG. **9** is a block diagram illustrating an example interface microservice configured to intercept network traffic routed by a vSwitch in accordance with the disclosed embodiments. In FIG. **9**, for example, an interface microservice **930** on a computing device **912** intercepts network traffic routed by a vSwitch **920** (e.g., network traffic sent and received by a VM **904** via VNIC **908**). When the VNIC **908** sends a network packet (e.g., based on a request generated by an application **906** or other source), the VM **904** includes an identifier of the port group **910** with the network packet. If the interface microservice **930** was not present in FIG. **9**, the network packets including the port group **910** identifier arrive at the vSwitch **920**, the vSwitch **920** determines a VLAN to which the port group **910** is assigned, and sends the network packet out network path **924** based on the determined VLAN.

In an embodiment, a VLAN assigned to a port group **910** as in the example above is referred to as an "original" or "existing" VLAN. In one embodiment, to enable an interface microservice **930** to intercept network traffic routed by the vSwitch **920**, the microservice creates a new VLAN, referred to herein as an "intercept" VLAN, for each original VLAN and further generates and stores a VLAN mapping **932** indicating a mapping from each original VLAN to a respective intercept VLAN. The interface microservice **930** further adds the original VLAN and the intercept VLAN to a VLAN trunk **922** enabling the traffic on both VLANs to be routed to an interface microservice **930**.

In an embodiment, based on the configuration described above, the interface microservice **930** can change the VLAN assigned to port group **910** of VM **904** from the original VLAN to the intercept VLAN and, consequently, packets sent from VM **904** are directed to interface microservice **930** via the VLAN trunk **922**. The interface microservice **930** can then translate the intercept VLAN **934** to the original VLAN

936 using the VLAN mapping **932**, and network traffic leaving network path **924** can be associated with the original VLAN.

Similarly, when a network packet is received by the vSwitch **920** coming in from the network path **924**, because the interface microservice **930** is now part of the VLAN trunk **922** for both the intercept VLAN and the original VLAN and the incoming network packets are associated with the original VLAN, the network packets are routed to the interface microservice **930**. The interface microservice **930** similarly maps the original VLAN to the intercept VLAN using the mapping **932**, and the packets are sent to the VM **904** using the VLAN trunk **922**. In this manner, the changes to the network structure at the hypervisor **902** and vSwitch **920** are transparent to outside devices which only are aware of the original VLAN.

3.0. Functional Overview

Approaches, techniques, and mechanisms are disclosed that enable a computer security application to intercept, filter, and perform security operations on network traffic sent from and received by VMs in a networked computing environment. In one embodiment, a computer security application configures a vSwitch to enable traffic routed by the vSwitch to be intercepted and filtered by an interface microservice. The interface microservice receives, from the vSwitch, configuration information including a mapping between at least one port group identifier and at least one VLAN identifier. For each existing, or "original," VLAN identifier in the configuration information, the interface microservice creates a separate "intercept" VLAN. The interface microservice adds the at least one existing VLAN, the at least one intercept VLAN, and the interface microservice to a VLAN trunk. The configuration information is modified to replace the existing VLAN identifiers associated with the port groups with identifiers of the intercept VLANs.

In an embodiment, based on the configuration described above, an interface microservice can receive and filter traffic routed by a vSwitch and configured with the intercept VLANs. For example, a vSwitch receiving network packets associated with an intercept VLAN routes the packets to the interface microservice via the VLAN trunk created above. The interface microservice can retrieve and apply various packet filters stored in association with the intercept VLAN to the network packets. If the packet filters match any of the intercepted network packets, the interface microservice can perform various security operations on the packets, send the network packets for security processing by an external microservice, or perform any other operations. Otherwise, the microservice can send network packets not matching the retrieved packet filters to the intended destination based on an original VLAN identifier stored in an intercept to original VLAN mapping.

In an embodiment, an interface microservice is an executable component of a computer and network security system, such as the system described in Section 2.0. As illustrated in FIG. **7**, for example, an interface microservice **730** configures a VM **704** and vSwitch **720** to route traffic through the interface microservice **730** to be filtered based on intercept configuration **732**. In an embodiment, network traffic matching a filter can be processed locally, or sent to an external security microservice **752** for additional security operations. For example, a security microservice **752** can perform

operations to determine whether network traffic matching the filter poses a potential security threat to computing device **712** or other devices.

3.1. Configuring a vSwitch for Traffic Interception

In an embodiment, security services provided to a VM **704** include intercepting and analyzing network traffic traversing a network path **724**. At a high level, an interface microservice **730** works with a vSwitch **720** to provide security services by filtering intercepted network packets, and by locally processing filtered packets or sending the filtered packets to one or more higher level security services via network path **734**. The higher level security services might reside on a different virtual machine on the same local physical machine, at another physical machine, or at any location accessible to an interface microservice **730**.

FIGS. **10**A, **10**B illustrate an example method of configuring a vSwitch to enable an interface microservice to intercept and filter network traffic routed by the vSwitch. At a high level, the method described in FIG. **10** inserts an interface microservice into a packet flow managed by a vSwitch in a way that is transparent to devices outside of the local area network(s) managed by the vSwitch. As described in more detail hereinafter, by enabling an interface microservice to transparently intercept network traffic at a vSwitch, the interface microservice can efficiently filter network traffic and determine whether to perform additional security operations on network traffic at the packet level. Although FIGS. **10**A, **10**B describes operations performed by a configuration microservice (e.g., a configuration microservice **202**), some or all of the operations described in FIG. **10**A, **10**B can be performed by a configuration microservice, an interface microservice (e.g., an interface microservice **730**), another type of microservice, an application, or any other computer-executable logic.

At block **1002**, a configuration microservice determines, for a computing device for which it is desired to intercept and filter network traffic, if an interface microservice is running at the computing device. At block **1004**, if an interface microservice is not currently running on the computing device, the configuration microservice installs an interface microservice (e.g., an interface microservice **730**). Otherwise, if an interface microservice is currently running on the computing device, the method proceeds to block **1006**.

In an embodiment, the computing device for which it is desired to intercept and filter network traffic includes at least one hypervisor, and at least one VM is running on the at least one hypervisor. As illustrated in FIG. **7**, for example, a computing device **712** might include at least one hypervisor **702**, where at least one VM **704** is running on the hypervisor. The at least one VM includes a VNIC **708** that is connected to a port of a vSwitch, which routes network traffic for a plurality of VNICs connected to the vSwitch.

In an embodiment, the vSwitch is associated configuration information which includes, for example, a port groups configuration **722**. The port groups configuration **722** includes information defining one or more port groups managed by the vSwitch, where each port group is associated with a set of member VNICs. For example, one port group of port groups configuration **722** might include VNIC **708** and some number of other VNICs of the VM **704** or other VMs. The port groups configuration **722** includes a VLAN associated with each port group.

At block **1006**, the interface microservice retrieves port groups information from the configuration for the vSwitch running on the computing device. As indicated above, the port groups configuration **722** indicates, for each port group, which VNICs (and associated VMs) are members of the port group and further identifies a mapping with an associated VLAN. In one embodiment, the set of VLANs associated with the port groups defined in a port groups configuration **722** of a vSwitch **720** is referred to herein as a set of existing, or original, VLANs.

At block **1008**, the configuration microservice creates, for at least one original VLAN identified in the port groups information, a corresponding intercept VLAN. For example, for each original VLAN associated with a port group from port groups configuration **722** of vSwitch **720**, a configuration microservice can create a corresponding intercept VLAN. In general, each of the intercept VLANs created at block **1008** represents an internal version of a corresponding original VLAN and can be used to route the original VLAN traffic to an interface microservice **730**, as further described in the following operations.

At block **1010**, the configuration microservice creates a mapping indicating the original VLAN corresponding to each intercept VLAN created at block **1008**. In one embodiment, the mapping is stored by the interface microservice **730** (e.g., illustrated in FIG. **9** as VLAN mapping **932**) such that an interface microservice **730** can translate network packets associated with an original VLAN into packets associated with an intercept VLAN, and vice versa. At block **1010**, the process of FIG. **10**A proceeds to block **1012** shown in FIG. **10**B.

At block **1012**, the configuration microservice optionally sets a default intercept action to "ignore" for each created intercept VLAN. For example, a configuration microservice might configure an interface microservice **730** initially to ignore network packets routed by a vSwitch **720** until further security processing is desired. In effect, setting an interface microservice's intercept action to "ignore" causes the interface microservice to operate in a "pass-through" mode, whereby packets received by the microservice are passed through the interface microservice without processing. In this example, an interface microservice **730** receives network packets associated with an intercept VLAN, translates the intercept VLAN to an original VLAN, and causes the network packets to be sent out a network path **724**. In this manner, other networked devices receiving the network packets via network path **724** can be unaware of the intercept VLAN originally associated with the network packets.

At block **1014**, the configuration microservice configures a VLAN trunk to include the original VLANs and the intercept VLANs. At a high level, a VLAN trunk is a network link used to carry traffic for multiple VLANs and to operate as a single logical link for multiple virtual links. In an embodiment, the VLAN trunk configured at block **1014** is able to carry traffic for both the original VLANs and the intercept VLANs created at block **1008**. As described above, network traffic can be associated with a particular VLAN based on a VLAN tag included with the network packets (e.g., by a VM **904** originating a network packet, an interface microservice **930** intercepting a network packet, or another device).

At block **1016**, the configuration microservice adds the interface microservice to the VLAN trunk. In an embodiment, adding the interface microservice to the VLAN trunk enables the interface microservice to receive network traffic associated with either the original or intercept VLANs (e.g., network traffic associated with an intercept VLAN by a VM **904** or network traffic arriving at network path **924** associated with an original VLAN).

At block **1018**, the configuration microservice modifies the port groups configuration at the computing device to use the intercept VLAN. For example, a configuration microservice can modify the port group **910** at a VM **904** to use the intercept VLAN mapped to the original VLAN. Based on the modification to the port group **910** configuration, the VM **904** includes a VLAN tag of the intercept VLAN with network packets sent from the VM **904**. As described in more detail in reference to FIG. **11**, because the network packets are associated with the intercept VLAN, the vSwitch **920** routes the traffic to the interface microservice **930** via the VLAN trunk **922**.

FIG. **11** illustrates an example system with an interface microservice configured using the method described in FIG. **10**. In an embodiment, a configured interface microservice **1130** includes an interface for network traffic associated with an intercept VLAN **1134**, an interface for network traffic associated with original VLAN **1136**, a packet filter **1140**, and a filter configuration **1132**. In an embodiment, a filter configuration **1132** enables the interface microservice **1130** to filter packets coming from VM **1104** (and any other VMs connected to the vSwitch **1120**) using the packet filter **1140**. If the packet filter **1140** does not match an examined network packet, the interface microservice **1130** applies the original VLAN **1136** mapping to the network packet and sends the packet out network path **1124**.

If the packet filter **1140** does match an examined network packet, the interface microservice **1130** can perform any operations relative to the network packet, including sending the network packet to another microservice on the same machine, sending the network packet to a security service running on another machine via network path **1138**. In the example of FIG. **11**, if a network packet is sent to a security service running on a separate machine, and if the security service allows the packet (e.g., because the packet did not raise any security concerns), the packet returns via network path **1138**. The interface microservice **1130** can then apply the original VLAN **1136** to the network packet and send the packet out network path **1124**. At a high level, a packet filter **1140** enables an interface microservice **1130** to quickly determine whether individual network packets warrant additional security processing (e.g., based on ports or IP addresses of interest, a size of the packets, etc.) before sending the network packets out to other devices. The configuration of FIG. **11** thus enables packet-level granularity for determining whether to apply additional security processing to packets arriving at the vSwitch **1120**.

For example, assume a network administrator desires to check for "poisoned" SQL queries. In this example, the security administrator may configure an interface microservice **1130** to filter network traffic associated with a connection to known SQL server address, or associated with web traffic containing a SQL query, and to send the filtered network traffic to another security microservice via network path **1138**. The external security process, for example, may then reassemble the network traffic, run various security checks, or perform any other processing to determine whether or not the network packets potentially carry a SQL injection attack. If the external security service determines that the network traffic is safe, the interface microservice **1130** allows the network packets to be sent out the network path **1124** to the originally intended destination. Otherwise, network packets which the packet filter **1140** determines are not related to SQL queries can bypass the additional security processing to avoid using additional computational resources at the external security service.

FIG. **12** is a block diagram illustrating an example of a filter configuration (e.g., a filter configuration **1132** shown in FIG. **11**). In general, a filter configuration **1132** can be used by an interface microservice **1130** to determine whether individual packets are subjected to additional security processing by the interface microservice **1130** or other microservices, as described above. In an embodiment, a filter definition (e.g., filter definition **1210**, **1220**) includes a filter name (e.g., filter name **1212**, **1222**), a filter VLAN (e.g., a filter VLAN **1214**, **1224**), filter criteria (e.g., filter criteria **1216**, **1226**), and a filter forward address (e.g., a filter forward address **1218**, **1228**).

In an embodiment, a filter name is a human-readable label for the filter (e.g., "SQL injection filter" or "DoS filter"). The filter VLAN indicates one or more VLANs to which the filter applies. For example, an interface microservice might perform packet filtering on network packets originating from multiple different VLANs, so filters can apply to particular VLANs. In some embodiments, a filter name is hierarchical such that a single human-readable label causes multiple functional filters to be employed concurrently. In some embodiments, a filter has dependencies on another filter, such that enabling a first filter causes at least one additional filter to be enabled concurrently.

In an embodiment, filter criteria include any rules, patterns, or other information used to determine whether a packet matches a filter. For example, filter criteria might include port numbers, IP addresses or IP address ranges, packet size thresholds or any other characteristic against which packets received by the microservice can be compared. In an embodiment, a forward address is a network address to which network packets are sent if the network packets match the packet filter. For example, the forward address might be an address of an external computing device which includes additional security services to be applied to packets matching the filter. As another example, a filter forward address might be a null value indicating that the filter can simply send network packets matching the filter out a default interface.

FIG. **13** illustrates an example method performed by an interface microservice to intercept and filter VLAN traffic. For example, in one embodiment, the method described in FIG. **13** can be performed by an interface microservice **1130** configured to intercept and filter network traffic based on the configuration described in reference to FIG. **10**.

At block **1302**, an interface microservice receives a packet from an intercept VLAN. For example, referring again to FIG. **11**, an interface microservice **1130** might receive a packet from an intercept VLAN **1134**, where the packet originates from a VM **1104** including a VNIC **1108**, which is a member of the intercept VLAN **1134**. The VM **1104** tags the packets sent from the VNIC **1108** with the VLAN based on the port group **1110** associated with the VNIC **1108**.

At block **1304**, the interface microservice identifies packet filters from a stored packet filter configuration that match the intercept VLAN. For example, an interface microservice **1130** receiving a packet tagged with an intercept VLAN can use the intercept VLAN identifier to locate packet filters associated with the intercept VLAN.

At block **1306**, the interface microservice applies the identified packet filters to the received packet. In an embodiment, a packet filter applied to a packet either matches the packet or does not match the packet based on one or more criteria specified in the filter.

At block **1308**, the interface microservice determines whether the packet matches the filter. If the network packet does not match the filter then, at block **1310**, the interface microservice forwards the network packet to the original VLAN. If the network packet does match the filter then, at block **1312**, the interface microservice forwards the packet to the address identified in the corresponding filter definition. As described above, the packet can be forwarded to another microservice on the same machine, to another machine, or any other location which can perform additional security operations on the packet to determine whether the packet is associated with any security threats.

4.0. Example Embodiments

Examples of some embodiments are represented, without limitation, by the following:

In an embodiment, a method or non-transitory computer readable medium comprises: retrieving, from a virtual switch (vSwitch) running in a computing environment, configuration information including a mapping between at least one port group identifier and at least one existing virtual local area network (VLAN) identifier; for an existing VLAN identifier from the configuration information, creating a separate intercept VLAN associated with an intercept VLAN identifier; adding the existing VLAN identifier, the intercept VLAN identifier, and an interface microservice to a VLAN trunk; modifying the configuration information to replace the existing VLAN identifier with the intercept VLAN identifier; receiving, from the vSwitch and as part of the VLAN trunk, a network packet from a virtual machine (VM) associated with the intercept VLAN; and determining whether the network packet matches a packet filter.

In an embodiment, a method or non-transitory computer readable medium comprises: wherein the computing environment includes a hypervisor, and wherein the VM is running on the hypervisor.

In an embodiment, a method or non-transitory computer readable medium further comprises: wherein the packet filter is one of a plurality of packet filters, and wherein the packet filter is associated with the intercept VLAN; and identifying the packet filter from the plurality of packet filters based on the association of the network packet with the same intercept VLAN.

In an embodiment, a method or non-transitory computer readable medium further comprises modifying the VM to use the intercept VLAN for network traffic associated with the VM.

In an embodiment, a method or non-transitory computer readable medium comprises: wherein the packet filter includes at least one filter criteria and a filter forward address.

In an embodiment, a method or non-transitory computer readable medium comprises: wherein the packet filter includes at least one filter criteria and a filter forward address, and wherein the filter forward address identifies a network location including a security microservice.

In an embodiment, a method or non-transitory computer readable medium comprises: wherein the packet filter includes at least one filter criteria and a filter forward address, and wherein the filter forward address indicates a network location to which to forward network packets matching the packet filter.

In an embodiment, a method or non-transitory computer readable medium comprises: further comprising, in response to determining that the network packet matches the packet filter, sending the network packet to a security microservice which performs one or more security operations on the network packet.

In an embodiment, a method or non-transitory computer readable medium comprises: further comprising, in response to determining that the network packet does not match the packet filter, modifying the network packet based on the existing VLAN identifier and forwarding the network packet to the existing VLAN.

In an embodiment, a method or non-transitory computer readable medium comprises: wherein determining whether the network packet matches the packet filter includes determining one or more of: whether the network packet is associated with a defined port, whether the network packet is associated with a defined IP address, whether the network packet exceeds a threshold packet size, whether the network packet exceeds a threshold packet length, and whether the network packet contains a defined type of content.

Other examples of these and other embodiments are found throughout this disclosure.

5.0. Implementation Mechanism—Hardware Overview

According to one embodiment, the techniques described herein are implemented by one or more special-purpose computing devices. The special-purpose computing devices may be desktop computer systems, portable computer systems, handheld devices, networking devices or any other device that incorporates hard-wired and/or program logic to implement the techniques. The special-purpose computing devices may be hard-wired to perform the techniques, or may include digital electronic devices such as one or more application-specific integrated circuits (ASICs) or field programmable gate arrays (FPGAs) that are persistently programmed to perform the techniques, or may include one or more general purpose hardware processors programmed to perform the techniques pursuant to program instructions in firmware, memory, other storage, or a combination thereof. Such special-purpose computing devices may also combine custom hard-wired logic, ASICs, or FPGAs with custom programming to accomplish the techniques.

FIG. **14** is a block diagram that illustrates a computer system **1400** utilized in implementing the above-described techniques, according to an embodiment. Computer system **1400** may be, for example, a desktop computing device, laptop computing device, tablet, smartphone, server appliance, computing mainframe, multimedia device, handheld device, networking apparatus, or any other suitable device.

Computer system **1400** includes one or more buses **1402** or other communication mechanism for communicating information, and one or more hardware processors **1404** coupled with buses **1402** for processing information. Hardware processors **1404** may be, for example, general purpose microprocessors. Buses **1402** may include various internal and/or external components, including, without limitation, internal processor or memory busses, a Serial ATA bus, a PCI Express bus, a Universal Serial Bus, a HyperTransport bus, an Infiniband bus, and/or any other suitable wired or wireless communication channel.

Computer system **1400** also includes a main memory **1406**, such as a random access memory (RAM) or other dynamic or volatile storage device, coupled to bus **1402** for storing information and instructions to be executed by processor **1404**. Main memory **1406** also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by processor **1404**. Such instructions, when stored in non-transitory storage media accessible to processor **1404**, render computer system **1400** a special-purpose machine that is customized to perform the operations specified in the instructions.

Computer system **1400** further includes one or more read only memories (ROM) **1408** or other static storage devices coupled to bus **1402** for storing static information and instructions for processor **1404**. One or more storage devices **1410**, such as a solid-state drive (SSD), magnetic disk, optical disk, or other suitable non-volatile storage device, is provided and coupled to bus **1402** for storing information and instructions.

Computer system **1400** may be coupled via bus **1402** to one or more displays **1412** for presenting information to a computer user. For instance, computer system **1400** may be connected via an High-Definition Multimedia Interface (HDMI) cable or other suitable cabling to a Liquid Crystal Display (LCD) monitor, and/or via a wireless connection such as peer-to-peer WI-FI® Direct connection to a Light-Emitting Diode (LED) television. Other examples of suitable types of displays **1412** may include, without limitation, plasma display devices, projectors, cathode ray tube (CRT) monitors, electronic paper, virtual reality headsets, braille terminal, and/or any other suitable device for outputting information to a computer user. In an embodiment, any suitable type of output device, such as, for instance, an audio speaker or printer, may be utilized instead of a display **1412**.

One or more input devices **1414** are coupled to bus **1402** for communicating information and command selections to processor **1404**. One example of an input device **1414** is a keyboard, including alphanumeric and other keys. Another type of user input device **1414** is cursor control **1416**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **1404** and for controlling cursor movement on display **1412**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allows the device to specify positions in a plane. Yet other examples of suitable input devices **1414** include a touch-screen panel affixed to a display **1412**, cameras, microphones, accelerometers, motion detectors, and/or other sensors. In an embodiment, a network-based input device **1414** may be utilized. In such an embodiment, user input and/or other information or commands may be relayed via routers and/or switches on a Local Area Network (LAN) or other suitable shared network, or via a peer-to-peer network, from the input device **1414** to a network link **1420** on the computer system **1400**.

A computer system **1400** may implement techniques described herein using customized hard-wired logic, one or more ASICs or FPGAs, firmware and/or program logic which in combination with the computer system causes or programs computer system **1400** to be a special-purpose machine. According to one embodiment, the techniques herein are performed by computer system **1400** in response to processor **1404** executing one or more sequences of one or more instructions contained in main memory **1406**. Such instructions may be read into main memory **1406** from another storage medium, such as storage device **1410**. Execution of the sequences of instructions contained in main memory **1406** causes processor **1404** to perform the process steps described herein. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions.

The term "storage media" as used herein refers to any non-transitory media that store data and/or instructions that cause a machine to operate in a specific fashion. Such storage media may comprise non-volatile media and/or volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as storage device **1410**. Volatile media includes dynamic memory, such as main memory **1406**. Common forms of storage media include, for example, a floppy disk, a flexible disk, hard disk, solid state drive, magnetic tape, or any other magnetic data storage medium, a CD-ROM, any other optical data storage medium, any physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EPROM, NVRAM, any other memory chip or cartridge.

Storage media is distinct from but may be used in conjunction with transmission media. Transmission media participates in transferring information between storage media. For example, transmission media includes coaxial cables, copper wire and fiber optics, including the wires that comprise bus **1402**. Transmission media can also take the form of acoustic or light waves, such as those generated during radio-wave and infra-red data communications.

Various forms of media may be involved in carrying one or more sequences of one or more instructions to processor **1404** for execution. For example, the instructions may initially be carried on a magnetic disk or a solid state drive of a remote computer. The remote computer can load the instructions into its dynamic memory and use a modem to send the instructions over a network, such as a cable network or cellular network, as modulate signals. A modem local to computer system **1400** can receive the data on the network and demodulate the signal to decode the transmitted instructions. Appropriate circuitry can then place the data on bus **1402**. Bus **1402** carries the data to main memory **1406**, from which processor **1404** retrieves and executes the instructions. The instructions received by main memory **1406** may optionally be stored on storage device **1410** either before or after execution by processor **1404**.

A computer system **1400** may also include, in an embodiment, one or more communication interfaces **1418** coupled to bus **1402**. A communication interface **1418** provides a data communication coupling, typically two-way, to a network link **1420** that is connected to a local network **1422**. For example, a communication interface **1418** may be an integrated services digital network (ISDN) card, cable modem, satellite modem, or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, the one or more communication interfaces **1418** may include a local area network (LAN) card to provide a data communication connection to a compatible LAN. As yet another example, the one or more communication interfaces **1418** may include a wireless network interface controller, such as a 802.11-based controller, BLUETOOTH® controller, Long Term Evolution (LTE) modem, and/or other types of wireless interfaces. In any such implementation, communication interface **1418** sends and receives electrical, electromagnetic, or optical signals that carry digital data streams representing various types of information.

Network link **1420** typically provides data communication through one or more networks to other data devices. For example, network link **1420** may provide a connection through local network **1422** to a host computer **1424** or to data equipment operated by a Service Provider **1426**. Service Provider **1426**, which may for example be an Internet Service Provider (ISP), in turn provides data communication services through a wide area network, such as the world wide packet data communication network now commonly referred to as the "Internet" **1428**. Local network **1422** and Internet **1428** both use electrical, electromagnetic or optical signals that carry digital data streams. The signals through the various networks and the signals on network link **1420** and through communication interface **1418**, which carry the digital data to and from computer system **1400**, are example forms of transmission media.

In an embodiment, computer system **1400** can send messages and receive data, including program code and/or other types of instructions, through the network(s), network link **1420**, and communication interface **1418**. In the Internet example, a server **X30** might transmit a requested code for an application program through Internet **1428**, ISP **1426**, local network **1422** and communication interface **1418**. The received code may be executed by processor **1404** as it is received, and/or stored in storage device **1410**, or other non-volatile storage for later execution. As another example, information received via a network link **1420** may be interpreted and/or processed by a software component of the computer system **1400**, such as a web browser, application, or server, which in turn issues instructions based thereon to a processor **1404**, possibly via an operating system and/or other intermediate layers of software components.

In an embodiment, some or all of the systems described herein may be or comprise server computer systems, including one or more computer systems **1400** that collectively implement various components of the system as a set of server-side processes. The server computer systems may include web server, application server, database server, and/or other conventional server components that certain above-described components utilize to provide the described functionality. The server computer systems may receive network-based communications comprising input data from any of a variety of sources, including without limitation user-operated client computing devices such as desktop computers, tablets, or smartphones, remote sensing devices, and/or other server computer systems.

In an embodiment, certain server components may be implemented in full or in part using "cloud"-based components that are coupled to the systems by one or more networks, such as the Internet. The cloud-based components may expose interfaces by which they provide processing, storage, software, and/or other resources to other components of the systems. In an embodiment, the cloud-based components may be implemented by third-party entities, on behalf of another entity for whom the components are deployed. In other embodiments, however, the described systems may be implemented entirely by computer systems owned and operated by a single entity.

In an embodiment, an apparatus comprises a processor and is configured to perform any of the foregoing methods. In an embodiment, a non-transitory computer readable storage medium, storing software instructions, which when executed by one or more processors cause performance of any of the foregoing methods.

6.0. Extensions and Alternatives

As used herein, the terms "first," "second," "certain," and "particular" are used as naming conventions to distinguish queries, plans, representations, steps, objects, devices, or other items from each other, so that these items may be referenced after they have been introduced. Unless otherwise specified herein, the use of these terms does not imply an ordering, timing, or any other characteristic of the referenced items.

In the foregoing specification, embodiments of the invention have been described with reference to numerous specific details that may vary from implementation to implementation. Thus, the sole and exclusive indicator of what is the invention, and is intended by the applicants to be the invention, is the set of claims that issue from this application, in the specific form in which such claims issue, including any subsequent correction. In this regard, although specific claim dependencies are set out in the claims of this application, it is to be noted that the features of the dependent claims of this application may be combined as appropriate with the features of other dependent claims and with the features of the independent claims of this application, and not merely according to the specific dependencies recited in the set of claims. Moreover, although separate embodiments are discussed herein, any combination of embodiments and/or partial embodiments discussed herein may be combined to form further embodiments.

Any definitions expressly set forth herein for terms contained in such claims shall govern the meaning of such terms as used in the claims. Hence, no limitation, element, property, feature, advantage or attribute that is not expressly recited in a claim should limit the scope of such claim in any way. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A computer-implemented method, comprising:

retrieving, from a virtual switch (vSwitch) corresponding to a hypervisor running in a computing environment, configuration information including a port group virtual network interface card (VNIC) list and a mapping between at least one port group identifier and at least one existing virtual local area network (VLAN) identifier, wherein the vSwitch tags a network packet with a VLAN associated with the port group included in the configuration information;

for an existing VLAN identifier from the configuration information, creating a separate intercept VLAN associated with an intercept VLAN identifier;

adding the existing VLAN identifier, the intercept VLAN identifier, and an interface microservice to a VLAN trunk;

modifying the configuration information to replace the existing VLAN identifier with the intercept VLAN identifier;

receiving, from the vSwitch and as part of the VLAN trunk, the network packet from a virtual machine (VM) associated with the intercept VLAN; and

determining whether the network packet matches a packet filter.

2. The method of claim **1**, wherein the computing environment includes the hypervisor, and wherein the VM is running on the hypervisor.

3. The method of claim **1**, further comprising:

wherein the packet filter is one of a plurality of packet filters, and wherein the packet filter is associated with the intercept VLAN; and

identifying the packet filter from the plurality of packet filters based on the association of the network packet with the same intercept VLAN.

4. The method of claim **1**, further comprising modifying the VM to use the intercept VLAN for network traffic associated with the VM.

5. The method of claim **1**, wherein the packet filter includes at least one filter criteria and a filter forward address.

6. The method of claim **1**, wherein the packet filter includes at least one filter criteria and a filter forward address, and wherein the filter forward address identifies a network location including a security microservice.

7. The method of claim **1**, wherein the packet filter includes at least one filter criteria and a filter forward address, and wherein the filter forward address indicates a network location to which to forward network packets matching the packet filter.

8. The method of claim **1**, further comprising, in response to determining that the network packet matches the packet filter, sending the network packet to a security microservice which performs one or more security operations on the network packet.

9. The method of claim **1**, further comprising, in response to determining that the network packet does not match the packet filter, modifying the network packet based on the existing VLAN identifier and forwarding the network packet to the existing VLAN.

10. The method of claim **1**, wherein determining whether the network packet matches the packet filter includes determining one or more of: whether the network packet is associated with a defined port, whether the network packet is associated with a defined IP address, whether the network packet exceeds a threshold packet size, whether the network packet exceeds a threshold packet length, and whether the network packet contains a defined type of content.

11. The method of claim **6**, wherein the security microservice is implemented using a container supporting a plurality of security operations including deep packet inspection and data loss prevention.

12. A non-transitory computer-readable storage medium storing instructions which, when executed by one or more processors, cause performance of:

retrieving, from a virtual switch (vSwitch) corresponding to a hypervisor running in a computing environment, configuration information including a port group virtual network interface card (VNIC) list and a mapping between at least one port group identifier and at least one existing virtual local area network (VLAN) identifier, wherein the vSwitch tags a network packet with a VLAN associated with the port group included in the configuration information;

for an existing VLAN identifier from the configuration information, creating a separate intercept VLAN associated with an intercept VLAN identifier;

adding the existing VLAN identifier, the intercept VLAN identifier, and an interface microservice to a VLAN trunk;

modifying the configuration information to replace the existing VLAN identifier with the intercept VLAN identifier;

receiving, from the vSwitch and as part of the VLAN trunk, the network packet from a virtual machine (VM) associated with the intercept VLAN; and

determining whether the network packet matches a packet filter.

13. The non-transitory computer-readable storage medium of claim **12**, wherein the computing environment includes the hypervisor, and wherein the VM is running on the hypervisor.

14. The non-transitory computer-readable storage medium of claim **12**, further comprising, in response to determining that the network packet matches the packet filter, sending the network packet to a security microservice which performs one or more security operations on the network packet.

15. The non-transitory computer-readable storage medium of claim **12**, further comprising, in response to determining that the network packet does not match the packet filter, modifying the network packet based on the existing VLAN identifier and forwarding the network packet to the existing VLAN.

16. The non-transitory computer-readable storage medium of claim **12**, wherein determining whether the network packet matches the packet filter includes determining one or more of: whether the network packet is associated with a defined port, whether the network packet is associated with a defined IP address, whether the network packet exceeds a threshold packet size, whether the network packet exceeds a threshold packet length, and whether the network packet contains a defined type of content.

17. An apparatus, comprising:

one or more processors;

a non-transitory computer-readable storage medium coupled to the one or more processors, the computer-readable storage medium storing instructions which, when executed by the one or more processors, causes the apparatus to:

retrieve, from a virtual switch (vSwitch) corresponding to a hypervisor running in a computing environment, configuration information including a port group virtual network interface card (VNIC) list and a mapping between at least one port group identifier and at least one existing virtual local area network (VLAN) identifier, wherein the vSwitch tags a network packet with a VLAN associated with the port group included in the configuration information;

for an existing VLAN identifier from the configuration information, creating a separate intercept VLAN associated with an intercept VLAN identifier;

add the existing VLAN identifier, the intercept VLAN identifier, and an interface microservice to a VLAN trunk;

modify the configuration information to replace the existing VLAN identifier with the intercept VLAN identifier;

receive, from the vSwitch and as part of the VLAN trunk, the network packet from a virtual machine (VM) associated with the intercept VLAN; and

determine whether the network packet matches a packet filter.

18. The apparatus of claim **17**, wherein the computing environment includes the hypervisor, and wherein the VM is running on the hypervisor.

19. The apparatus of claim **17**, further comprising, in response to determining that the network packet matches the packet filter, sending the network packet to a security microservice which performs one or more security operations on the network packet.

20. The apparatus of claim **17**, further comprising, in response to determining that the network packet does not match the packet filter, modifying the network packet based on the existing VLAN identifier and forwarding the network packet to the existing VLAN.

21. The apparatus of claim **17**, wherein determining whether the network packet matches the packet filter includes determining one or more of: whether the network packet is associated with a defined port, whether the network packet is associated with a defined IP address, whether the network packet exceeds a threshold packet size, whether the network packet exceeds a threshold packet length, and whether the network packet contains a defined type of content.

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